The Silviculture and Profitability of Plantation Forestry in New Zealand

by

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Acknowledgements

The sources of the unpublished data used here have, wherever possible, been acknowledged directly with an appropriate reference. Inevitably much unpublished cost data of the New Zealand Forest Service have been used, and the help of M. B. Grainger in obtaining these data, particularly for the post-devaluation studies, is gratefully acknowledged. J. D. Mackintosh and M. R. Hosking, working for the writer, took half of the measurements involved in the growth comparisons of Appendix 2. The regrading of 'Hull's trees' was carried out by I. G. Trotman; planning and computations were by the writer. Direct data on grade yields of integrated mills were supplied on a confidential basis by Tasman Pulp and Paper Co. Ltd. and by New Zealand Forest Products Ltd.

The grade study of 'Cpt. 28, Waiotapu' which provided an essential part of the data for the PR II regime was completed with the help of W. R. J. Sutton and J. R. Tustin; L. Knowles assisted in calculating the results. The Algol programme for an Elliott 503 computer was written in conjunction with J. W. Williams, and thanks are due to the Applied Mathematics Laboratory of the New Zealand Department of Scientific and Industrial Research for use of the computer.

The silvicultural approach of the PR II regime is the end result of a considerable amount of research, and W. R. J. Sutton's help in supplying branch size data, and in solving the growth projection problem for this regime is acknowledged.

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The profitability calculations are primarily case studies based on a specific locality - the Maraetai area - which has been described and evaluated in an earlier study (Ward et al, 1966). It is indicated in Chapter 8 that the Maraetai area is characteristic of much of the Bay of Plenty, and is of the average site quality for Douglas fir in the North Island. The Maraetai area's value as a sample is thus considerable as comparisons can be made with earlier findings, and results applied over wide areas, accordingly it has been used here.

The work, with the exceptions noted above, is the result of the original work of the writer.

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SUMMARY

Part I. Silviculture and end uses of exotic species.

Softwoods predominate in the exotic forests of New Zealand. Areas of 50 acres or more occupy over 900,000 acres; of these, more than half are in State forests. The two major species are radiata pine (1) and Douglas fir. 43 per cent of the 600,000 acres of radiata pine and 95 per cent of the 75,000 acres of Douglas fir are in State forests, as are over 80 per cent of the remaining - minor - softwood species. The latter have no superior commercial, or complementary technical properties to those of the major species and their planting is now limited to about ten per cent of annual State afforestation. New planting by the State is planned to be 75 per cent of radiata pine and 15 per cent of Douglas fir, and analysis largely concerns these two species.

New Zealand grown Douglas fir has pronounced inequalities of texture within an annual ring which render it generally unsuitable for boards; but if knot-size and annual ring width are sufficiently restricted, the relative strength and stability of the

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(1) Biological names are given in Appendix 1.

timber favour its use as framing. Radiata pine is also generally satisfactory for framing if knot-size is restricted, but its smooth finishing qualities favour use as boards. Factory grade - of short clear-cuttings - is often produced from untended radiata pine. In pruned logs the radial extensions of occlusion scars initially preclude recovery of full length clears, and Factory grade is usually the first grade recovered from this intermediate zone after pruning. Radiata pine is more suitable for mechanical and chemical pulp, providing over 90 per cent of the pulpwood currently used; Douglas fir is less favoured because its extensive, dry, coloured heartwood increases pulping costs.

Roundwood products are a minor market. Douglas fir roundwood seasons relatively easily whereas radiata pine is more susceptible to decay in seasoning. This initial advantage of Douglas fir has been supplanted by improved practice for radiata pine which can also be more deeply penetrated by preservatives. Douglas fir can only be effectively treated with oil-soluble preservatives whereas radiata pine can be treated with both oil and water-soluble preservatives.

Mis-siting of Douglas fir has resulted in its elimination over extensive areas. Releasing is necessary if weed competition is vigorous. Pruning is unnecessary for framing production, but dense stocking is required to suppress branch diameter growth; the technically desirable death of the lower branches in densely stocked stands is rapid after age 30. The relative height growth of Douglas fir and radiata pine is constant over a wide range of sites and age classes; local and North American Douglas fir tree volume tables show very close agreement and support a suggested volume solution (Spurr, 1963) for yield projection. A synthesis of these height and volume data, with current mortality trends and the two hitherto independent yield projections showed Douglas fir can produce intermediate net yields per acre of 3,000 cu. ft at age 35 and 3,250 cu. ft at age 42 with a net final yield of 10,200 cu. ft at age 50, on sites equivalent to an index of 95 ft (Lewis, 1954) for radiata pine. This is 20 years less than generally prescribed. Dense stocking is unnecessary for radiata pine grown for board production; timing and execution of pruning is critical. A modified current management prescription - PR I - retains 180 stems per acre (s.p.a.) (1) at age 10-12; 100 s.p.a. are removed in thinning

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(1) Abbreviations are listed in Appendix 1.

at age 18-20 yielding 2,300 cu. ft net per acre; the final 80 s.p.a. are clearfelled at 36 years yielding 9,000 cu. ft net per acre. Tree selection should be determined on characteristics of the lowest logs with decreasing weight given to progressively higher logs. Adequate tree selection is possible by 35-40 ft stand height as, if all logs are ultimately sawn, over 60 per cent of sawn output and probably over 80 per cent of net value are represented in the two lowest logs. A regime - PR II - designed to promote maximum growth on the pruned final crop trees by early thinning to waste and avoidance of production thinning exploits both the early selection possible, and the formidable diameter growth potential of radiata pine. The full yield prediction (Beekhuis, 1966) for radiata pine has been reduced by 25 per cent in basal area until 75 ft top height to comply with trends of the relatively few areas thinned at the required intensity - to 150 s.p.a. at 35 ft top height and 80 s.p.a. at 55 ft.

Part II. Profitability

Profitability calculations of long term investments involve compounding (or discounting) to allow for the effect of time. The criterion of present net worth (P.N.W.) is traditionally used in forestry as the land expectation value (L.E.V.), where P.N.W. is expressed per unit area, and the cost of land is evaluated as a residual. For 'normal' forests the L.E.V. is found by the Faustmann formula. Recent developments in public resource allocation have not substantially altered the principles established in the Faustmann approach, but its uncritical use in evaluating expanded afforestation programmes can give optimistic results if sufficient allowance is not made (in the charge for indirect costs) for the high level of capital costs incurred before additional areas are planted. Projects can be evaluated by the internal rate of return (I.R.R.) they generate. The I.R.R. has more limiting assumptions than the P.N.W. as it can lead to non-optimal ranking of alternatives and to multiple solutions. The P.N.W. can also give anomalous results if values are negative as P.N.W. values can improve as interest rates rise. Ratios of costs and returns are sensitive to definitions of net cost. An annual budgeting approach has been used to find, primarily, the L.E.V. and I.R.R., as the main aim is comparison within forestry. All criteria tested gave generally similar ranking of projects. It is concluded that as long as the analyst is conversant with the limitations of the criteria, any combination which is appropriate to the particular problem can be used.

Forest rent aims at maximizing annual yield (monetary and/or volumetric); if interest on the capital cost of the forest is ignored, forest rent is economically invalid, but the principle is still widespread in forestry.

A subjective choice of an interest rate is inevitable, and an empirical choice based on current internal rates in agriculture - a comparable land-using, export-oriented industry - has been made, with recognition of the long term, internal, Government borrowing rate. (Imports comprise only five per cent of forestry costs). A range of four to seven per cent is generally used in the profitability analyses.

Allowances for uncertainties should not be made by arbitrary adjustment of either interest rates, or of costs, as the effects may be disproportionate. The annual risk of fire losses, at present levels of protection, is less than 0.1 per cent.

The value of indirect benefits has been particularly stressed in forestry. The high accident rate in logging, the high labour turn-over and the difficult social structure of management-owned, one-industry settlements are costs; the low rate of strikes in forests and sawmills are benefits and contrast with an above-industry average in pulpmills. Exotic forests, as currently administered, have limited scenic or recreational benefits. Conservation benefits - of land and wild-life - are considerable. Forestry and its derivative industries have favourable balances in imports and exports; the multiplier effect of further processing is considerable, and analyses of the two major species are extended to the end of primary industrial manufacture.

Douglas fir profitability was calculated for three management regimes which varied by the onset of clearfelling in conversion to normality from ages 30 and 35 to 42 years. Results were obtained with and without social costs, with and without inclusion of the sawmill, and for three price ranges. If domestic prices apply the high volume and piece-size increment from ages 30 to 50 enable the I.R.R. of about six per cent to be maintained with little variation due to rotation. The relative similarity of profitability gives a welcome flexibility to management as decisions to either fell smaller trees earlier with a loss of volume increment, or to obtain greater volumes at a later age can be taken with little difference in profitability.

The inescapable difficulty of low yields up to age 30 results in high compounded costs. Inclusion of sawmill capital and profit, while considerably increasing L.E.V. at lower interest rates, raises the I.R.R. by a range of only 0.2 to 0.6 per cent for the different regimes and prices tested. I.R.R. drops sharply to four per cent if export, instead of domestic prices, are used.

Profitability results (from a project of the same scale as that tested for Douglas fir) of radiata pine from PR I are slightly lower in L.E.V. and I.R.R. than the most favourable Douglas fir regime, if all sales are domestic. The sawing cost for radiata pine appears to be high in relation to that calculated in detail for Douglas fir, and if reduced by 40 cents per 100 bd.ft, I.R.R. of PR I and Douglas fir are both just over six per cent; at four per cent interest L.E.V. for Douglas fir are higher, at seven per cent interest L.E.V. for both species are negative, being worse for Douglas fir. Inclusion of the cost and range of profits of a pulpmill raise the I.R.R. of PR I to 8-11 per cent. The relative profitability of a pulpwood, and a pulpwood/sawlog forest (including the respective utilization plants) are analysed for radiata pine over a range of profit levels for pulp.

I.R.R. from the forest only, managed on the PR II regime, are over nine per cent, and L.E.V. are higher than under any combination of forest and mill tested for Douglas fir.

Effects of post-devaluation prices and costs were tested for the radiata pine regimes. Net results are moderately improved, the heavy increase in costs of capital equipment being more than offset by increases in export prices. The I.R.R. for PR II is over ten per cent. Sensitivity analyses for PR II show relatively slight, and probable, changes in utilization costs and in realizations far outweigh effects of extreme changes in most other costs.

Social costs - of accommodation and roading - have been isolated for each regime tested. As direct comparisons of silvicultural regimes and of species are required, it is considered that social costs should be included in calculation of net profitability, as they largely reflect the relative labour requirements. Social costs are lower for Douglas fir; the quicker tempo of PR II results in the highest costs; the personnel required at 'normality' are not substantially different for the regimes tested.

Part III. Limitations and Conclusions.

Shortcomings in basic data include contradictory management records and inadequate costs. The absence of detailed data on cost of logging, on timber grades from different age - and treatment-classes of the major species and of the cost of sawing restrict analysis. Lack of direct economic incentive in the past is probably reflected in high current costs. Profitability is sensitive to relatively small changes in sawing cost, and the correlation of mill type and capacity, with the log size distribution and volume from Douglas fir resulted in a lower overall cost than that assumed, on poorer data, for radiata pine. Sawing and logging costs are based on only a gross 40 hour week, and reflect the inefficient use of capital in present practice. Earlier assumptions of grade improvement from pruning are shown to be optimistic.

The dominance of the pulp and paper industry in New Zealand by a few firms dependent on the State for raw materials and/or control of tariff and trade policies may reduce the chances of objective analysis, as data may be withheld in the firms' self interests.

The relative risks of the two major species are difficult to quantify; Douglas fir probably has a greater marketing and a lesser degree of biological risk than radiata pine. A higher level of management skill is required for radiata pine. If the growth potential of radiata pine is exploited - as in PR II - it is more profitable than Douglas fir. Allowance for the further processing possible for radiata pine - illustrated for PR I - increases its advantage over Douglas fir. The earlier emphasis of pruning of Douglas fir, at an average age of 30 years, in preference to young radiata pine, and the support of overseas authorities for Douglas fir was misplaced.

Past forest policy of replacement of indigenous by exotic supplies has been successful, and New Zealand now has a favourable balance in forest products trade. While lack of tending precludes the present day production of higher timber grades, the failure of integrated and other mills to gain the advantage of the supply potential available from the untended resource is due to inadequate appreciation of factors causing degrade, inability to direct logs to the best end-uses and reluctance to kiln-dry framing timber. Past, and much present day, silviculture has lacked direction, much of the 100,000 acres of 0/18 ft pruned stands will result in little additional benefit. Lack of economic incentive and analysis, combined with failure to appreciate the complex morphology and, even now, the great growth rate of radiata pine results in indifferent levels of management. Past concentration of planting in time and place resulted in sufficient areas being available to start large-scale pulp industries, but this economically favourable aspect of past policy is now apparently discarded. Errors in management are exemplified by the indifferent pruning programme, the poor execution of thinning prescriptions, the relative failure to obtain major produce in production thinning, the lack of proper integration of forest and mill, the lack of concentration of current planting, and the comparative absence of accurate costs. These faults can be largely rectified in future if economic analysis accompanies management proposals. Economics may not be the deciding factor in a final decision, but the relative cost of the course of action proposed, and of the alternatives should at least be known.

The silvicultural rationalization epitomized in PR II shows that concentration not only on the final crop trees, but also on specific logs, and the comprehension of the effects of their associated characteristics in relation to grade can greatly increase profitability. The fundamental concept of plantations is to manipulate the crop profitably to obtain the desired end product.

Plantation forestry could yield good returns if concentrated planting, short rotations, and directed silviculture are used to exploit the remarkable growth potential of radiata pine.

PREFACE

(a) BACKGROUND TO THE STUDY

While New Zealand has a high per capita overseas trade, exports are based on a narrow range of pastoral products, as the country is relatively poor in natural resources. Diversification of the economy would lessen the risks of undue reliance on pastoral products. As the growth rates of several exotic softwood tree species in New Zealand are exceptionally high, a degree of comparative advantage could be anticipated from plantation forestry. The analyses of some possible silvicultural regimes and determination of their relative profitability is the main point of the study.

(b) THE BASIS OF THE STUDY

There are two fundamental aims - the first is to demonstrate the range of disciplines and data required, particularly in silviculture and forest utilization, to obtain meaningful results from economic studies of forestry, and to provide an empirical basis for analysis.
The second aim is the exposition of silviculture in plantations. The crux of technically successful plantation forestry is the ability to recognize that, while gross volume of the tree trunks is naturally of basic importance, it is equally fundamental to produce the qualities required for given end uses within these

trunks. This technical foundation - if it is to succeed economically - must take cognizance of the relatively high cost of waiting before yields are obtained in forestry. The synthesis - reached in a regime called PR II - aims at obtaining a high level of technically acceptable produce as quickly as possible.

(c) OUTLINE OF THE STUDY AND EXTENT OF ORIGINAL DATA (1)

There are three main sections covering silviculture, economics, and discussion and conclusions; inevitably there is some overlap between them. The physical and silvicultural basis of the study is given in Chapters 1 to 4. The exotic forest estate is enumerated in Chapter 1 from the literature cited. Douglas fir (2), which is apparently a profitable species, is discussed in Chapter 2 and the reasons for its technical success given there and in the accompanying paper (Fenton, 1967a). Original data include: timber grade results; an analysis of the relative growth rates of Douglas fir, radiata and

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(1) Acknowledgements to other workers has been specifically made in the earlier section; the listing here is to indicate where new data are presented, and where previously existing data are collated for the study.

(2) Biological names are listed in Appendix 1.

Corsican pine; and an analysis of why initial marketing of Douglas fir was apparently easy. Existing figures are used: to analyse death of the green crown; for the synthesis of two differing yield projections (Duff, 1956; Spurr, 1963); to the application of such sawing costs as are available in New Zealand; to suggesting regimes without thinning; and to use of shorter rotations than prescribed to date.

Radiata pine is a faster growing, more complex species than Douglas fir, and past management is critically examined in Chapter 3. This is supplemented by an original analysis of pruning results, and of timber grade; and an approach for silviculture based on concentration on the relative value of log-height classes (1) and tree morphology. Other original data comprise: the grade results from second-rotation trees of the appropriate size and age; the growth projections for heavily thinned young stands; the basis for correct comparison of pruning results (Fenton, 1968a); and the investigation of silvicultural efficiency in management. Existing data are collated on mill and study grade results; on the regrading of timber from an earlier grade study; and on the future supplies of boards and framing timber.

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(1) Viz: the butt log of 18ft is the lowest such class; the log length from 18 to 36ft is the second log-height class, and so on.

Chapter 4 is a brief résumé from the sources cited of the extent and quality of exotic softwoods, other than Douglas fir and radiata pine.

Chapters 5 to 9 deal primarily with economics. The criteria of profitability are reviewed in Chapter 5; apart from demonstrating the anomalous effect of increasing interest rate on land expectation value (tested as a result of a comment by J. T. Ward), and warning against over-facile use of the Faustmann formula in analysing expanded afforestation, the Chapter is primarily a critical review. Chapter 6, which deals specifically with choice of an interest rate is similar; fire risk is shown to be relatively low.

Chapter 7 is concerned with indirect economic and other effects; enumerating environmental influences; social effects within and outside the industry; and derivative economic effects. External data are analysed on: strikes, labour turn-over and accident rates; the social effects of forestry; economic multiplier and net overseas exchange benefits. The analysis of profitability beyond the forest ride is extended, as far as data allow, to saw - and pulp-mills in Chapters 8 and 9. Chapter 8 analyses Douglas fir profitability, testing three physical regimes, at a range of interest rates and at three or more price levels. The Maraetai area (Ward et al, 1966) was taken as a convenient basis for analysis, but as the site index was demonstrated to be the average for Douglas fir in the North Island, and the area is characteristic of much of the Bay of Plenty region, the analysis has wide application; the original area serves as a convenient sample. The originality in this Chapter lies in: the analyses of profitability of this species; in demonstrating the favourable domestic price structure of the species; and in the inclusion of the utilization plants in the analysis. The fundamental cost data are adopted from an earlier study (Fenton and Grainger, 1965).

Chapter 9 is basically similar to Chapter 8, and tests of radiata pine's profitability are made for several physical regimes. One regime had been evaluated previously (Fenton and Grainger, op. cit.) and this formed an initial basis for a sensitivity analysis for grade, price and sawing cost; more fundamentally, the results are again extended both to investigate the effects of including utilization plants in the analyses and to update results to post devaluation levels. The new regime - P R II - evolved in Chapter 3 is tested under pre - and post - devaluation costs and prices and a comprehensive sensitivity analysis was made of effects of changes in costs and prices. The originality lies in finding far higher profitability levels than previously demonstrated; in showing the relative importance of various costs, and in illustrating the low value of pulpwood - as a net stumpage - in plantations based on forest ride prices.

Underlying the price structures used in Chapters 8 and 9 were the concurrent negotiations on trade with Australia (Fenton, 1968b), with the possibility of more favourable sales on this market. In the event, no extra allowance appears to be required, and the trade potential is analysed in a separate attached paper (Fenton, 1968b).

The third and final section, of Chapters 10 to 12, covers limitations, comparisons between species, and conclusions. Limitations in the studies, and in the data are enumerated in Chapter 10, with an outline of the minimum data required for optimising. The two major species are compared in Chapter 11, and contrary to overseas opinion (Muir, 1954; Spurr, 1961; Zobel, 1965) it is demonstrated that radiata pine is economically the better species. (This has presumably been recognized, *de facto*, for many years by the preponderance of radiata pine in afforestation). The difficulties of making predictions of relative biological risks are demonstrated, with examples from the literature.

The reasons for the failure of integrated mills to achieve high levels of timber exports are analysed in Chapter 12, and the timber export potential indicated. The role of economics in forestry at local and national levels is discussed, with reference to particular difficulties of analysis in New Zealand. The conclusions made in Chapter 12 are inevitably influenced by many facts and opinions, and it is difficult to judge how far they are original, but it is contended that at least in their total effect, there is much that is new.

PART 1 SILVICULTURE

CHAPTER 1 - THE EXOTIC FOREST ESTATE OF NEW ZEALAND

(a) THE EXOTIC FOREST AREA

Trees of exotic species were planted from the earliest days of European settlement in New Zealand - oaks, for example, were introduced in the 1820's in Northland (Weston, 1957). The first large-scale exotic plantings (of almost 2,000 acres) were made after 1879 by the then Canterbury Plantation Board, following the Province's 'Tree Planting Encouragement Act' of 1871 and earlier measures (Cooney, 1949). State planting began in the 1890's and the total area in 1920 was 38,000 acres. Private plantings, though small individually, totalled about 150,000 acres by 1920 (Yska, 1967).

The next decade was marked by extensive afforestation, reaching a climax in 1929-1931 when over 50,000 acres in State, and almost 40,000 acres in private forests were planted annually. The State planted 41,000 acres in 1932, but thereafter afforestation diminished, in 1939 only 2,700 acres were planted; private plantings similarly decreased. From 1940 to 1955 on average only 3,960 acres per year were planted in State forests, while private afforestation had almost ceased. Renewed, but less abrupt acceleration of planting began in 1956 both by the State and by private companies; by 1967 the State was planting 21,000 and private organisations 12,000 acres annually. As a result of this planting the total estate is now over 1,000,000 acres with a mal-distribution of age-classes (Table 1-1). Forest distribution is shown on the maps at the end of the Appendices. The history of afforestation is given elsewhere (Foster, 1947; Cooney, 1949; Kennedy, 1957; Entrican, 1960; Coughlan, 1964); forest policy is discussed in Chapter 12.

(b) THE EXOTIC FOREST SPECIES

A wide range of species was planted initially, but a Royal Commission recommended concentration on four softwoods: radiata, Corsican and ponderosa pines, and Douglas fir; as well as hardwoods: poplars and some Eucalypts (Anon, 1913). By 1926, private planting was predominantly of radiata pine, but the State planted large areas of other softwoods. Current net areas of major species are given in Table 1-2; post-1940 State plantings are summarised in Table 1-3; the age-class distribution of radiata pine is given in Table 1-4. Now State policy is for 75 per cent of all plantings to be of radiata pine; 15 per cent of Douglas fir and 10 per cent in other conifers (Anon, 1968a); there is an even greater preponderance of radiata pine in private planting.

(c) THE ANALYSIS

Past afforestation has resulted in: a maldistribution of age-classes; an almost exclusive concentration of private forestry on radiata pine; and a quarter of the total area, largely in State forests, being of species other than radiata pine. The management and silviculture of the exotic species which have been planted on any scale are discussed later together with possible utilization alternatives. A division into 'first-crop' taken as pre-1950 and 'second-crop' - 1951 and after distinguishes between those areas now beyond fundamental changes by silviculture, and the younger stands which have had more directed management. (The actual year of division is not, of course, absolute). Since future afforestation is now largely based on two species, profitability analyses are confined to 'new-crop' Douglas fir and radiata pine; Douglas fir silviculture and management being the subject of Chapter 2.

TABLE 1 - 1 EXOTIC FOREST ESTABLISHMENT

Years	Area (000 Acres)[1] State	Private	Total
Pre 1921	37	150[2]	187
1921-25	25	14	39
1926-30	185	204	389
1931-35	154	129	283
1936-40	31	37	68
1941-45	16	1	17
1946-50	16	2	18
1951-55	24	14	38
1956-60	37	20	57
1961-65	76	41	117
1966	21	12*	33*
1967	21	11*	32*
Total	643	635	1278

(1) Sources: Yska (1967); N.Z. Forest Service records
(2) Predominantly in small areas (less than 50 acres)
* Figures are provisional

TABLE 1 - 2 EXOTIC FOREST AREAS

- BY SPECIES

Species		Total major areas (1) 000 acres	Approximate per cent of the species contained in State Forests
Pines			
Radiata	(2)	620	43
Corsican	(2)	64	95
Austrian		5	75
Ponderosa	(2)	80	)
" ,scopulorum variety		6	) 85
Lodgepole	(2)	27	90
Muricata		6	90
Pinaster		11	25
Southern pines			
Slash	(2)	5	95
Patula		3	95
Longleaf		2	95
Loblolly		3	95
Other genera			
Larch		9	85
Douglas fir	(2)	75	95

(1) Source - National Exotic Forest Survey figures; supplemented with other N.Z. Forest Service records.

(2) Important species - because of their present extent, or future potential.

TABLE 1 - 3 STATE AFFORESTATION 1941 - 1967

(all areas in 000 acres)

Years	Species						
	Radiata pine		Corsican pine		Douglas fir		Total[1]
	Area	Per cent	Area	Per cent	Area	Per cent	Area
1941-50	11.1	35	5.5	17	2.8	9	31.3
1951-60	28.2	46	7.8	13	13.1	21	61.5
1961-65	47.6	62	7.9	10	12.0	16	76.4
1966	15.1	74	2.1	10	3.0	15	20.5
1967	15.2	72	1.1	5	4.1	19	21.2

(1) Includes other species not enumerated separately.

(2) Sources: N.Z. Forest Service 1957; 1962; 1967.

TABLE 1 - 4 CURRENT AGE-CLASS DISTRIBUTION OF RADIATA PINE

Years	State Forests (1) Area (3)	Per cent (4)	All major forest areas (2) Area (3)	Per cent (5)
Pre 1921	1.5	N.A.	2.7	0.6
1921-25	7.8	21	13.6	2.4
1926-30	131.5	72	227.0	40.4
1931	23.4	65	87.1	15.5
2	2.0	12		
3	0.6	2		
4	1.1	9		
5	0.9	7		
1936-40	5.6	17	35.5	6.3
1941-45	14.6	47	17.4	3.1
1946-50			54.5	9.7
1951-55	11.5	46	47.4	8.4
----- (6)				
1956-60	16.6	46	65.9	11.7
1961-65	47.6	62	N.A.	N.A.

(1) Figures from Forest Service records; Weston, (1957) and N.Z. Forest Service, 1966.

(2) Areas from National Exotic Forest Survey.

(3) In thousand acres.

(4) Per cent of all species planted in that year.

(5) Per cent of radiata pine age-class standing in 1960.

(6) Division between 'first-crop' and 'second-crop'

These data represent standing areas, in contrast to the areas planted.

CHAPTER 2 - THE MANAGEMENT AND SILVICULTURE OF DOUGLAS FIR

The physical limitations, end uses and grades of Douglas fir, when grown as an exotic in plantations are discussed in this Chapter. The growth characteristics and past silviculture are analysed; the relative growth rates of Douglas fir and radiata pine assessed and a detailed analysis is made of production from thinned and unthinned stands. The Chapter is concluded with silvicultural proposals for the species, which are the basis for economic analysis in Chapter 8.

(a) END USES; GRADE RESULTS

The end use of Douglas fir, when the tree is grown to at least 50 years of age, is essentially as framing timber, with minor outlets for round produce and, as boards, for such uses as laths, tile-battens and in farm buildings. The contrast in density between the early and latewood of an annual ring (an increase of 100 per cent or more according to Harris and Orman, 1958) together with a relatively low number of rings-per-inch produce inequalities of texture that are unsatisfactory for most dressed (viz. machine surfaced) timbers. While quarter-sawn edge-grain stock from slow (seven or more rings per inch) and evenly-grown logs may be suited for high-grade flooring and joinery if clear of knots (Reid, 1962), it is unlikely that this will be grown deliberately in New Zealand plantations. Too long a rotation would be needed, to reach a mean d.b.h.(1) of 21 in. a perfectly tended stand would take 80 years (Fenton, 1967a). This is more than twice the time that radiata pine requires to produce first-class finishing (2) timber in clear grades (Reid, 1953). Even with heavy thinning, the 100 largest stems per acre (s.p.a.) of Douglas fir after 50 years of age will grow only at six rings or more per inch (Spurr, 1963). Greater volumes of finishing grades could be produced from shorter rotations of radiata pine. The appropriate balance of finishing timber from Douglas fir has been indicated by the statement: 'it is desirable to prune a small percentage of the trees to be handled on long rotations to provide clears for joinery and large diameter logs for plywood' (Reid, 1962).

The requirements for satisfactory framing timber are strength, straightness and stiffness, which depend on the basic density, straightness and shrinkage characteristics of the stem wood and the size and condition of the branches. Investigations of the density of New Zealand-grown Douglas fir have shown it to be as dense and strong, but also as variable as North American material from second-growth stands (Harris and Orman, 1958).

(1) Abbreviations are listed in Appendix 1; d.b.h. = diameter breast height (at 4ft 6 in.)

(2) Finishing timber - specifically boards of Dressing, Finishing or Clears grade (N.Z. Standards Inst., 1962).

Their analysis included silvicultural considerations and recommended an initial spacing of 6 x 6 ft , with subsequent thinning to maintain not less than five rings per inch, in order to achieve a desirable basic density and a reasonable growth rate (Harris and Orman, op. cit.). In practice, much of the Douglas fir established before 1923 and after 1940 has been planted at 8 x 6 or 6 x 6 ft ; 8 x 8 ft spacing was generally used in the intervening years.

Tests with stress-grading machines have shown that grain-distortion associated with large knots has a greater degrading effect on framing than ring-width or pith (Whiteside, 1968). Since grain distortion is greater around live than dead knots, a critical factor affecting Douglas fir timber is the size and condition of the knots. Studies on timber sawn from over 800 logs from thinnings of 8 x 8 ft planted stands (1) showed proportions of 7:1:2 and 8:1:2 for good, intermediate and low framing qualities of 3 x 2 in. and 4 x 2 in. sizes, based on interim grading rules similar to those for pines (N.Z. Standards Inst., 1962). Timber is currently sold ungraded but rulings should be made to segregate the poorest material, which is inferior to pine for most uses. (Reid, 1962).

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(1) By the writer in 1967-68; these, with Whiteside's work on stress grading, have been the only ones made on local Douglas fir timber grades.

Inequalities of wood properties affect lamination to some extent as scarf joints between late and early wood cause greater variability in the properties of random joints; this effect can be minimised by good design (G. Stanger, pers. comm.).

Sapwood is accepted for kraft pulp; the coloured heartwood is avoided where possible because it increases bleaching costs; pines are preferred to Douglas fir for both groundwood and chemical pulping (Reid, 1962).

From 1941 until the mid-1950's Douglas fir (and larch) dominated the small scale round-produce market, and pines were rarely used. The relative merits of Douglas fir and radiata pine for round produce are discussed elsewhere (Fenton, 1967a); Douglas fir can only be treated with oil-soluble preservatives, whereas pine can be treated with either water - or oil-soluble preservatives. There are now over 200 widely distributed preservation plants treating pine but only three to treat Douglas fir, and the earlier dominance of Douglas fir on this market has been lost.

The branching habit of Douglas fir has been reported as horizontal (Hinds and Reid, 1957) in contrast to the generally angular branching of radiata pine, but the pendulous nature of the relatively thin fir branches probably gives this effect; the branches where they leave the trunk are at angles comparable to those of pines.

This is exemplified in published photographs (Plate 4 of Weston, 1957: Plates 1 and 3 of Harris and Orman, 1958; Fenton 1967a). Consequently degrade of wood due to crescents of bark on the upper side of knots does occur but, since the major use is framing not boards, this defect is of less consequence than in radiata pine. The branching pattern has been described as lacking defined nodes (Reid, 1963) and, in general, the branching is less clustered than, for example, Corsican pine. In a few trees branching is more or less in annual clusters but, even in these, large numbers of small branches (0.1 to 0.5 in. diameter) occur between major whorls. The net effect is to greatly reduce the number of boards which it would be possible to grade as equivalent to Factory (N.Z. Standards Inst.,1962) or as North American Shop grades; again, as the timber is for framing, this is unimportant. The more dispersed nature of the branching pattern results in less chance of concentration of defects and, with the small branch-size of the timber milled to date, favours the use of the species for framing.

Details of the development of the green crown level in New Zealand grown Douglas fir are given elsewhere (Fenton, 1967a); in unthinned stands the base of the green crown is at 30 to 40ft by about top height 70 ft, and by top height 100ft it is approximately 75ft (Fenton, op. cit.). The critical age for the rapid and technically desirable death of the lower crown is between 30 and 40 years. As with natural stands in North America and in European plantations, branches are strongly persistent and natural pruning is as slow, or slower than for radiata pine (Fenton and Familton, 1961). Until 1962 the great majority of thinning operations had occurred at or after age 40, and hence in the three or four lowest sawlogs the branches were dead and relatively small. This condition was therefore fixed for any subsequent yield from the most important part of the remaining trees. Much of the timber sawn from top logs (namely, from the green crown of second thinnings at age about 55) has been of poor quality, being degraded by large live knots of more than two in. diameter. The remarkable reaction of Douglas fir to delayed and heavy thinning (Spurr, 1961) is achieved at the inevitable cost of enlarged branches in the remaining crown above about 75ft. If the species is to be grown on long rotations, timber from these upper log-height classes will occur more frequently and will be akin to Box grade of radiata pine. Economically, this material may be more than compensated for by the excellent grades of framing from the lowest three or four log-height classes. In calculating the value of long rotations, prolonged height growth and the ensuing development of further heavy branches after thinning will have to be assessed against increased log diameters in the three or four lowest logs. Removal of the lower dead branches by falling trees during thinning operations certainly reduces the incidence of future defects, provided a sufficiently long time interval elapses between thinning and clear-felling (Fenton 1967b); it is rarely sufficient to produce long clear lengths, but this is less important for framing than for board timber.

Pruning is unnecessary for Douglas fir, but at least 16,000 acres were pruned to 18ft in State forests by 1963 - a greater area and a far greater percentage than pruned in radiata pine (Fenton, 1967a).

The predominant use for Douglas fir is, therefore, as sawn timber, and in particular as framing timber.

(b) GROWTH CHARACTERISTICS AND PAST SILVICULTURE

A succinct account of silviculture is available (Weston, 1957) together with supplementary information (Spurr, 1961; Hinds, 1962). These do not discuss the branch characteristics which determine the quality of the timber, but past silviculture has been ideal for an end-use as framing timber. The stands utilized to date have been generally well-planted and fully stocked, so having the first essentials for quality. Failures have been either complete (Kirkland, 1968) or else trees have remained small (four to six ft high). In contrast, radiata pine often survives on severe (namely, frosty) sites and although badly malformed continues to grow taller; the resultant trees and stands possessing excessive malformation, often with 40 to 60 per cent of the stand volume accounted for by malformed trees - data for Karioi forest are quoted elsewhere (Fenton, 1967a). In pure stands of Douglas fir the canopy is generally complete by top height 20 to 25 ft and lack of mortality, when combined with good establishment, leads to rapid suppression of the butt-log branches and their relatively early death. Apart from branches on wolf trees and on open-grown trees in canopy gaps, average branch diameter is less than 1.5 ins. in most stands. Height growth, once canopy is complete, is fairly rapid (Duff 1956). Mortality is markedly less than in unthinned radiata pine stands in most areas, and hence thinning can be delayed until age 40 to 45 without undue volume loss. Generally stem form is good, with an absence of gross malformation but small deviations in the leading shoot can result in considerable cross-grain and subsequent loss of strength.

The obvious disadvantage in the management of Douglas fir is the long time interval before thinning is both possible and technically desirable. In one private forest, wider spacing allows thinning at age

24 (Spurr, 1961). The resultant stands produce coarser timber than from later thinnings of more closely spaced stands but this material has been accepted to date by the market.

Thinning with extraction has hitherto been delayed until a large volume (5,000 cu.ft per acre) can be cut (Fenton, 1967a). On steep country tractors are cheaper than haulers but the thinning intensity is greater. Steep country results in higher costs, particularly if haulers are used, and residual stocking is lower. By thinning at age 30, a reduced yield is associated with both higher costs and lower realizations, resulting in small or even negative returns. Thinning intensities have been heavy, partly to recover the operating costs of the tracked tractors and mechanized loaders used to date. The use of cheaper equipment such as wheeled farm tractors has not been followed for extraction operations, despite the generally favourable topography of the stands thinned to date.

(c) GROWTH RATE AND YIELDS

The relative height growths of radiata (and Corsican) pine and of Douglas fir have been compared. Assessment of 41 pairs of compartments where the two species occurred on the same site and were of the same age gave a regression:

Predominant mean height (P.M.H.) of Douglas fir (1)

= 0.782 P.M.H. radiata pine - 13.4 (all heights in feet)

(Details are in Appendix 2). This compares well with earlier results (Duff, 1956), but the earlier comparisons of Douglas fir and Corsican pine reduced the growth index for Corsican pine. For a site index (Lewis, 1954) of 95 ft for radiata pine comparative heights would be:

radiata pine	P.M.H. (ft)	40	60	90	120	140
Douglas fir	" "	18	33	61	80	96
" "	age (years)	9	13	20	26	36

The P.M.H. of 96 ft at age 36 is close to the 95 ft at age 35 given as the mean for North Island pumice sites (Spurr, 1963).

Yield prediction is complicated by two sets of results. Height-growth projections in the first (Duff, 1956) were found to be 'quite conservative in forecasting future heights above the range of data then available' (Spurr, 1963) in the second; but the comprehensive stem-diameter and volume-distribution

(1) Predominant mean height - the mean of the tallest trees on each 1/40th of an acre.

data available earlier have not been recalculated. The data available from Spurr's results are the top heights (1), basal areas and volume yields of unthinned stands, and of stands thinned on schedules given to the Permanent Sample Plots (2). Such schedules are too intensive to be used commercially on current costs. The two projections are closest at age 35, where data for unthinned stands of top height 95 feet are:

	Duff, 1956	Spurr, 1963
Basal area (B.A.)	324 sq.ft (8x8ft spacing)	355 sq.ft (mainly 8x8ft spacing)
Volume (to 6 in. top)	9,820 cu.ft	9,500 cu.ft

Spurr's yield prediction based volume on a North American regression of basal area and top height, while Duff's originated from local measurements of Hartig mean-trees on 'volume-line' methods, and above 90 ft, was based on only 13 plots. Spurr argued that as Duff's solution showed some curvilinearity 'at greater top heights [than 82 ft ?]' (Spurr, 1963), the North American solution 'based as it is on older and taller stands' was applicable. The degree of curvilinearity shown in Duff's solution is slight, being a weak S-shaped curve. Similar trends for radiata pine originally treated as curvilinear (Lewis, 1954) gave satisfactory straight-line regressions (Beekhuis, 1966).

(1) Top height is the mean height of the 100 trees of largest diameter per acre.

(2) Permanent Sample Plots of the N.Z. Forest Research Institute.

The only possible check was comparison of two-way tree volume tables for New Zealand (Burstall, 1959) and for North American second-growth Douglas fir (McArdle et al, 1961; Worthington and Staebler, 1961); these showed close agreement. The local stands appear to be more densely stocked than those in North America (Fenton, 1967a), and so theoretically have less taper. Results for radiata pine showed regressions of volume on basal area and top-height were unaffected by different stand densities (Beekhuis,1966), though the applicability of results from one species to another is uncertain. Spurr's solution has been adopted, as the volume-table agreement is close and recent yield calculations in Kaingaroa are '... in accord with the average trend established by Spurr' (Kirkland, 1968).

(d) SILVICULTURAL PROPOSALS FOR PROFITABILITY ASSESSMENT

As production of framing timber is the object of management, the only silvicultural restraint necessary is the suppression and early death of branches to restrict defect size in the lower log-lengths, and the restriction of radial growth to not less than five annual rings-per-inch (Harris and Orman, 1958). These conditions are achieved, as in past silviculture, by maintaining a dense stocking, and postponing thinning to age 35 (Fenton, 1967a). Projections of the stem diameter distribution at this age are taken from Duff's results, and are summarised in Appendix 3.

Technical prescriptions of Rotorua Conservancy are for unduly long, and so expensive, rotations (Fenton, 1967c); substitution of a 50 year rotation, with thinnings at ages 35 and 42 would give earlier yields; the differences being summarised in Table 2-1. Full projections of stem diameter distribution and volumes for such a regime are given in Appendix 4; log sizes were calculated from taper tables for each thinning and clear-felling class.

The management regime is given in Chapter 8, with an economic analysis.

TABLE 2 - 1 YIELDS OF DOUGLAS FIR

(95 ft P.M.H. at 35 yrs)

Unthinned stands

Age yrs	P.M.H. ft	B.A. sq.ft	s.p.a.	6in. top vol. (1)	Mean d.b.h. in.
30	80	316	550	6,300	10.3
35	95	347	500	8,900	11.3
40	108	369	439	11,200	12.4
45	120	397	410	13,450	13.3
50	130	419	370	15,350	14.4

Thinned stands - proposed regime

Age yrs	P.M.H. ft	B.A. sq.ft	s.p.a.	6 in. top vol. (1)	Mean d.b.h. in.	B.A. sq.ft	s.p.a.	6in. top vol. cu.ft	Mean d.b.h in.
		Thinnings				Residual Crop			
35	95	143	320	3,000	9.0(2)	205	180	6,690	14.4
42	110	95	80	3,250	14.7	173	100	6,735	17.8
50	130	235	100	10,200					20.8
				16,450					

Rotorua Conservancy proposals (3)

Age yrs	P.M.H. ft	B.A. sq.ft	s.p.a.	6 in. top vol. (1)	Mean d.b.h. in.	B.A. sq.ft	s.p.a.	6in. top vol. cu.ft	Mean d.b.h in.
(35)	95		3-400	5,500			220		
(45)			140	4,000			70-80		
70				9,000					

(1) Net logged volume, cu.ft per acre (allowing for logging losses).

(2) Ignoring trees of 6 in. d.b.h. and under.

(3) N.Z. Forest Service records.

CHAPTER 3 - THE MANAGEMENT & SILVICULTURE OF RADIATA PINE

Radiata pine is a more complex species than Douglas fir as its morphology is more variable, and its end-uses are more diverse. A discussion of end-use is followed by analysis of grade results from research studies, and from integrated and non-integrated utilization plants. The results of pruning are analysed. The growth characteristics which affect grade are enumerated, and the extent and efficiency of past silviculture analysed. Yield prediction is even more complex than for Douglas fir, as the Permanent Sample Plots have not received a sufficiently wide range of treatment to allow fully based projections to be made for heavily thinned stands. A rationalization, based on value out-turn per log height class and on the relative failure of production thinning to date, leads to a new alternative regime in the treatment of radiata pine.

(a) END USES: TIMBER GRADES OF 'FIRST-CROP' STANDS

Over 60 per cent of total timber production over the last three years has been of radiata pine (against five per cent from Douglas fir). Timber quality of radiata pine is reviewed elsewhere (Reid, 1953; 1963; 1965); it is the most versatile of the exotic species. Uses range from box-making and concrete form-work; to construction uses as light framing; heavier construction and laminating timber; railway sleepers and finally for higher finishing quality uses as flooring, weatherboards, and joinery.

Radiata pine almost entirely dominates pulp and paper making, less than seven per cent of the logs used were of other species in 1967. It comprises almost all of the export trade in logs.

Due to the ease with which it can be treated by preservative processes, it has now supplanted Douglas fir and larch in the round-produce market.

Greater quantities of high-grade boards (1) could be sold if more were available, but the 'first-crop', comprising three-quarters of the total area has received little tending (Kennedy, 1957; Entrican, 1960). Grade results from milling have been supplemented by grade-studies, but both have limited applications. Mill results are influenced by markets, pre-1950 results were affected by post-war timber shortages. This situation was abruptly reversed when overall exotic-timber capacity was increased by a third in 1953 by the opening of the integrated mill of N.Z. Forest Products Ltd., and by a third again in 1954 by the advent of the Tasman Pulp and Paper Co. Ltd., while the Waipa State mill - hitherto the largest - also doubled capacity.

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(1) High grade boards: Dressing and Finishing grades. Elaboration of the grade specification (N.Z. Standards Inst., 1962) is made in Ward, 1957.

Naturally, full capacities were not attained, and grading standards became high. In the South Island, by contrast, there is still only one medium-size (10 to 15 million bd. ft per year production) mill, competition is less keen and there is sufficient demand from heavy construction markets (e.g. dams and harbour works) to enable much of the cut to be sold as large sizes of Merchantable grade. Again, mills may have to produce non-standard sizes quickly to fill orders, and all timber may go into only one or two grades.

Anomalies presented by grade-studies have been discussed (Fenton and Fairburn, 1966; Fenton, 1967b) and a uniform method proposed to reduce the variables incurred, and to permit better comparisons. Grade-study results tend to be more pessimistic than those from mills due to literal grade interpretations. Few results are available for timber after kiln-drying and dressing, which are processes which test finishing grades. Advent of stress-grading machines will reduce variations in interpretation for framing grades; kiln-drying and dressing will reduce variation in finishing grades. Against this 'pessimism', grade-studies have been largely confined to trees of normal form (Beaumont results - Fenton, 1965a - are an exception) whereas mill results represent a fuller cross-section of the stands.

Results from mills and from large-scale studies are given in Tables 3-1 to 3-3, they contain apparent anomalies explained below.

Changes in demand have influenced results, there has been a steady increase in the quantity of framing required. In 1954 most radiata pine was sawn to one-inch boards, but now about 55 per cent of the cut is framing timber. This is reflected by four of the five pairs of years included in mill results. For the fifth case - Mill III - the log supply comes from younger private plantings (from 1935 onwards) and here the difference in age of the log supply is critical, the younger stands giving relatively better results from sawing to boards, a fact appreciated from grade-study results.

Secondly, there are regional differences, with a smaller proportion of Box grade from the South Island mills. There are three reasons for this. The suppression and death of branches is slowest in Nelson and fastest in Canterbury (sawmilling in Canterbury sensibly reflects this by cutting predominantly framing). In addition to the differential death of the green crown and its effects on grades (Fenton, 1967b) the South Island stands are both more fully stocked and of lower overall site quality.

Much of the encased-knot zone has been included in the last 20 years of radial growth and thus has either degraded narrow, outer boards or has been removed in sawmill slabs (Fenton and Familton, 1961; Fenton, 1967b). In addition, branch sizes are generally smaller. Consequently grade returns are better from boards than in the North Island, as the defects now found in the trees are not yet numerous in the timber. The best timber-quality stands are on phosphate-deficient sites around Auckland, where the combination of low site-quality, small branch-size, persistence of green crown and better overall form leads to fewer critical defects.

Thirdly, the indifferent results of integrated saw-and pulp-mills have to be explained. This is partly due to their design, they were indifferently integrated until 1967. In mills I and III small diameter logs are segregated in the forest for the pulp-mill, but other logs are sawn regardless of defect - apart from a small proportion (five per cent) of the worst defects which are split out and pulped. In Mill II all logs enter a common set of skids and a higher degree of integration occurs, but due to inadequate design elsewhere the desirable integration (Entrican, 1957) does not occur. For example, before 1964, if the sawmill waste hogger broke down all logs were diverted to the pulp-mill;

a break in chip supply will initially divert all logs to the sawmill and later to the pulp-mill. The mill log flow was a function of time, rather than of log-quality. With mill extensions, log supply integration is improving. The results of Mill II are amongst the best nationally, but largely at the expense of sawmill conversion; recovery is only 25 to 35 per cent, as much of low-grade timber is pulped <u>after</u> sawing; the cost of such a source of pulp material is considerable.

Yields of Dressing (or better) grades from grade-studies are usually below those obtained in mill practice; the highest proportions are around 12 per cent in both cases from old stands. Grade-studies show a greater proportion of Factory grade is available, when compared with mill results. This is partly explained by the mills' policy of requiring over 60, instead of 50 per cent of the piece in two-foot or longer clear-cuttings to allow safety margins to graders working at speed. Results from 'first-crop' pruned trees are scarce due to lack of tending; the most intensive study has been of a belatedly pruned (70 ft top height for 0/18 ft pruning) stand, summarised results are given in Table 3-4. This study (Fenton, 1967b) showed the presence of a small knotty-core and hence early pruning, was necessary to produce good yields of clearwood, confirming earlier projections (Fenton, Sutton and Drewitt, 1963).

It also confirmed Factory grade was the first and Clears the ultimate, result from pruning, as in Southern pines (Williams, 1960). The belated pruning yielded only seven per cent extra clearwood from the butts, regardless of sawing method, but Factory grade yields were double those of unpruned butt logs, comprising 40 per cent of the timber sawn.

A better pruned, but limited sample of 12 trees - 'Hull's trees' was sawn (Brown, 1964; 1965) (Table 3-4). Since the sample was then unique, it was regraded by another research team with lower yields of high quality board grades (1). The conflicting results are analysed (Fenton, 1968a) and the discussion summarised in Appendix 5; the main reason for the difference being the failure in the original study to mark timber for docking (even if it remained physically undocked) and so to fully allow for wane and primary defects. The regrading results were in sufficient detail to allow corroboration of grades from the basic data recorded. The growth of Hull's trees is discussed in Appendix 5 and was exceptional for New Zealand with a relatively early termination in height growth and a high diameter/height ratio.

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(1) Apart from timber of two butt logs, which was unavailable to the second team.

Trees in the eastern Wairarapa appear to grow as in South Africa and South Australia (Fenton, Sutton and Irvine, 1963; Bunn, 1967) in contrast to the continued height growth with age which is more characteristic of New Zealand. The high yield of Dressing grade from Hull's trees was partly due to the pruning of half the third-logs, to the reduction in the number of total defects by pruning the two lowest logs and to the stand-margin status of the trees. The Dressing grade here was largely an alternative form of the Factory grade recorded elsewhere as the first results from pruning.

Financial benefits from pruning (Brown, 1965) are shown to be exaggerated (Fenton, 1968a) (Appendix 5): the control trees contained more critical defects, regardless of pruning, and their overall conversion was much lower; the total and differential costs of sawing were ignored; there was a marked loss of width premium in both samples; the controls were not sawn to best advantage, and price discounts were not taken from gross realizations (as they would normally be). Consequently, the application of the results is restricted to the regraded yield of Clears from nine butt and eleven second-logs (results from the smallest tree being ignored) and further, allowance has to be made for the unusually favourable growth pattern of Hull's trees.

Results of the Kaingaroa and Hull's studies show that if trees of 22 in. d.b.h. have been pruned in frequent stages, then a third of the butt-log timber will be Clears, and a half Dressing and Factory grade. If trees of 25 in. d.b.h. have been belatedly pruned, yields of Clears will be a twelfth of the butt-log timber, with up to half its volume in Factory grade. Well executed successive pruning of the second-log can yield a quarter Clears and over a third in Dressing and Factory grade if trees are 23 in. d.b.h. or larger. Overall results per acre depend on the yield of intermediate crops, and the proportion of logs which are pulped.

As the 'first-crop' ages, framing grade potential will increase due to the decreasing curvature of the annual rings, the lesser grain angle of older wood, increasing density and, more importantly by the decreased incidence of defects as the chord between branches increases with growth in girth (Fenton, 1967b). Unpublished (1960) data (of J. A. Kininmonth) showed the proportion of framing timber with acceptable distortion increased with increasing depth in a kiln-stack from 49 to 76 per cent. Recent (1967) studies showed the proportion of unacceptably distorted framing timber is less than 10 per cent (J. S. Reid, pers. comm.) if stacks are weighted before drying.

This accords with South Australian developments where the earlier finding 'that butt logs ..... up to about $13\frac{1}{2}$ in. s.e.d. are undesirable for framing production' (Lewis, 1965) but afterwards log size was found not to be critical (Anon, 1967a).

The proportion of Factory grade, which comes mainly from butt- and second log-height classes, with lesser proportions from the third logs (Fenton and Familton, 1961; Fenton,1967b) will increase as these log diameters increase, since the grade depends on the branching pattern of the tree and, unlike other board grades except Clears, does not deteriorate with increase in tree age. Finger-jointing is profitable if 50 per cent of the timber yields clears of one foot or longer, and the Factory grade from the untended Kaingaroa 8 x 8 ft stands yield 70 per cent of such short clears. Therefore possibly 10 to 15 per cent of the cut could be available for conversion to finger-jointed clears (Fenton, 1967b). This could restore a balance towards the 20 per cent clears suggested as a national requirement (Reid, 1962).

If some Box and No. Two Framing grade is still required, the following grade production would be possible if finger-jointed material is sal⁀able:

Grade (N.Z. Standards Inst., 1962)	Proportions - per cent		
	Current	Possible	
Box	45-50	20	Reduce by cutting framing and finger-jointing.
Merchantable	10-20	10	Maintain at 10 per cent.
Dressing and better	2- 5	3	" - demand never satisfied.
No. One Framing	18-27	35	Increase (to season for export)
No. Two Framing	8- 9	12	Reduce proportion if possible.
Finger-jointing, or Factory grade; allow $7\frac{1}{2}$ per cent loss in total volume-diverted as source of chips.	5	20	Increase, at the cost of loss in total volume.

The pattern of grade production from the ageing 'first-crop' is of a deteriorating yield of board grades - apart from Factory grade; an increase in the quality of framing; regional differences reflecting site-quality and crown characteristics; and an overall lack of success of the integrated mills to produce higher proportions of good grades in quantity. Pruning has been late and will largely result in increased Factory grade production.

Modified results from Hull's trees can be used for grade projections for similar sized trees.

(b) GROWTH CHARACTERISTICS AND PAST SILVICULTURE

The growth characteristics which affect pulp and timber quality are largely a function of the size and longevity of the branches relative to stem diameter; in radiata pine this is further complicated by its heterogeneous morphology, and its variety of end uses.

Pith (and its associated defects of single- and double-spike knots; of low-density core-wood, and of differential longitudinal shrinkage and, often, spiral grain) is an unavoidable defect (1). It affects between 10 and 20 per cent of all sawn timber, the proportion depending on log size (Fenton and Familton, 1961; Fenton, 1967b). The material '...consisting principally of immature wood should be accepted as having a very low value for timber and other uses' (Reid, 1963).

The final size of branches, their variation in size in any log-length; their longevity; and distribution (2) are of 'extreme degrading importance' (Hinds, 1962) in

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(1) 'Pith' is used throughout as a convenient collective for this complex of degrading factors.

(2) Termed 'nodality' by foresters; 'uninodal': branches tending to be concentrated at only one or two points annually. By strict botanical definition trees cannot have 'nodes', the correct term is 'pseudo-clusters' (Bannister, 1962), but 'node' and 'uninodal' are used here partly for brevity, and partly as their usage is condoned in forestry.

radiata pine boards. From 40 to 60 per cent of some Kaingaroa 'first-crop' stands 39-42 years old were affected with bark-encased knots (Fenton, 1967b) (1); they were the most important cause of board degrade in other 'first-crop' stands (Fenton and Familton, 1961; Reid, 1963). Variation in knot diameter, particularly the production of pin knots (of 0.5 in. or less in diameter) results in differential death of the crown. Divergent accounts of the ability of thinning to maintain deeper crowns (Whiteside, 1962; Beekhuis, 1965) may be explicable: Whiteside studied young stands, whereas Beekhuis's analysis was based on 12 year and older stands. Growing trees in the correlation curve trend plots in South Africa (O'Connor, 1935) at a wide spacing initially results in a purely pyramidal crown, whereas reducing the stocking to the same level by thinning maintains a relatively cylindrical lower-crown beneath a pyramidal upper-crown (E. H. Bunn, pers. comm.). Similar effects have been observed in local stands (Sutton, 1968), and treatment of stands of less than 12 years of age possibly can maintain deeper crowns than those recorded by Beekhuis in the Permanent Sample Plots. The subject warrants further research, as even a few years longer

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(1) These defects averaged between 13 and 18 in number per 100 bd. ft of all timber sawn from the first 100 ft of the trees.

life may result in a larger intergrown knotty core (Fenton, 1967b). As the branches are moribund, there is usually little or no increase in knot diameter. The size of knots is more critical for framing timber, (board grades are infrequently degraded by size of knots) and, as for Douglas fir, high-grade framing is best produced by dense stocking and early death of the lower crown.

Knots in both mechanical and chemical pulping are preferably small, and alive. The resinification of knots after death (Harris, 1961) increases bleaching and chemical costs; the percentage of 'fines' is increased by the steep angle at which stem wood surrounding knots is ground at the stone surface; large knots tend to burn grinder surfaces reducing pulp yields. Critical data on the specific effect of these variables are not available. Kraft pulp yields increase with age, whereas mechanical pulpwood is preferably heartwood-free and its brightness decreases with increasing tree age.

Cone holes (1) are the third major cause of board degrade (Fenton and Familton, 1961; Hinds, 1962); their net effect is to degrade what would otherwise be Dressing

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(1) Radiata pine produces cones on its trunk, these are usually persistant (in New Zealand) and the stem of the cone leaves a cylindrical hole through the radius of the trunk. Cone holes are strictly 'stem-cone stem-holes'.

grade from top-logs. Other less important degrading factors are enumerated elsewhere (Fenton, 1967b).

Past silviculture has been limited, only 23 per cent of the total area pruned in State forests up to 1963 was of radiata pine; of the 90,000 acres of all species thinned from 1947-1964, only one per cent was on-schedule in 'second-crop' radiata pine stands for extraction of major produce (viz. saw or pulp-logs).

Thinned stands were assessed to find how closely results agreed with prescriptions, (Table 3-5). Whether the prescriptions are desirable or not, thinning intensities are generally heavier than prescribed (Fenton, Mackintosh and Hosking, 1965). As most regimes prescribe second or third production thinnings, the absence of standing trees could embarrass future management; another effect will be to increase the size of the remaining trees. The incidence of logging damage and the tree malformation, and the extent of pruning was also assessed; in the three stands thinned to final stocking in Whaka forest, for example, the number of normal form, undamaged and 0/18 ft (or higher) pruned stems left were 26, 31 and 40 per acre. After the first of the two planned production thinnings at Kaingaroa, 70 s.p.a. were left, these included both 0/18 ft pruned and undamaged stems, but 39 of the 70 had some malformation. Better stem selection resulted at Ngaumu where 100 0/18 ft pruned, normal form, undamaged s.p.a. remained after a first thinning for minor forest product (fencing material). The limited areas of extraction thinning to date (1) precludes calculation of an accurate correction factor to apply in financial calculations, when allowing for both thinning returns and growth of the remaining stand.

To date, thinning operations with extraction of major produce have been confined to country workable by tractors; steeper land has not been thinned (except to waste).

(c) GROWTH RATES AND YIELDS

Comprehensive yield tables are available for unthinned (Lewis, 1954) and thinned (Beekhuis, 1966) radiata pine. Once site index (Lewis, 1954) and basal area for stands of about ten years of age are known, full stand projections can usually be made. But 'the (basal area) data for very young stands are especially important because it is not yet possible to obtain a clear picture of the change from free-growth ... to restricted growth after canopy closure' (Beekhuis, 1966).

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(1) The areas shown as thinned in 1963 (N.Z. For. Serv., 1963), are incorrect, the Rotorua Conservancy figures for the four species-groups are given as 1,350, 71, 37 and 23 acres, but should be 248, 676, 478, and 79.

When the full projected basal area increment is allowed on stands thinned early to a low stocking, optimistic trends result, and the yield projection calculated in Appendix 6 allows only three-quarters of the full basal area increment until top height 75 ft is reached. Hence only recourse to the published yield tables is required to make projections for a stand, for example, planted at 640 s.p.a.; thinned to waste to 180 s.p.a. at 45 ft top height and (production) thinned to 80 s.p.a. at about 95 ft top height. But a regime requiring earlier and heavier thinning - to 150 s.p.a. at 35 ft and to 80 s.p.a. at 55 ft has to be calculated on the basis of such growth trends that are available; details are given in Appendix 6.

(d) SILVICULTURAL PROPOSALS FOR PROFITABILITY ASSESSMENT

End uses have to be defined, as varying silvicultural prescriptions will be necessary to achieve different aims. The great merit of radiata pine is its potential for producing clearwood (on pruned logs) in a comparatively short time (Reid, 1953). Pruning must be early to avoid a large core (Fenton, Sutton and Drewitt, 1963) and thinning is required to maximise clearwood production on pruned stems (and to some extent to keep branches alive). Silviculture for framing production is the antithesis - stands must be kept dense to reduce branch-size and to suppress the lower crown (subsequently thinning may increase final log size). A national management solution could be provided by adapting varying site qualities to best advantage, pruning should be concentrated on sites of high quality which in any case incur mortality earliest (Beekhuis, 1966; Jackson, 1955). The lower site qualities can be largely used for framing production - for example, Canterbury 60, Southland 70-75 (Hinds, 1955) Karioi 70, where high stocking and hence volume have been maintained (e.g. volumes of 13,400 cu. ft per acre at 40 years in Southland - Fenton and Brown, 1963).

Management proposals, both of private companies and Forest Service Conservancies, now include production thinning and, often, second-log pruning. (Oddly, there are no specific plans for producing framing timber from radiata pine). Hence the first model included is largely that of the Rotorua Conservancy, as detailed in the original profitability model (Ward et al ,1966; Fenton and Grainger, 1965). Modifications were made to improve pruning, and the regime is summarised in Table 3-6 as the 'PR I' regime. 'PR I' represents the ultimate reduction of classical forestry - the production-thinning operations being reduced to a minimum of one.

The volume of radiata pine (of major produce) from production thinnings of stands 25 years or younger in 1967 was less than 1.5 per cent of the annual production of the species (Tustin, 1968). Most of this 1.5 per cent was, in fact, from 23 - 24 year old stands of exceptional size (120 ft) - at Rotoehu forest. The assessments summarised in Table 3-5 show production thinnings result in:

(a) an18 to 41 per cent lower stocking than prescribed;

(b) butt-log damage, of uncertain significance, to about 25 per cent of the remaining trees;

(c) leaving only 35 to 55 0/18 ft-or-higher pruned final crop trees, after final thinning.

The need for lower extraction costs has been stressed (Fenton and Brown, 1963), but total costs average 10 to 12.6c. per cu.ft , if the Rotoehu operations are included (Tustin, 1968), compared with the clearfelling costs of half this, or less. The timber grades of these thinnings showed outturn will not be better than: 40 per cent Box; 22 per cent Merchantable, and up to 38 per cent in better grades (Tustin, op.cit.). A subsequent study of 20 year old thinnings from a 'fully-tended' stand at Gwavas gave interim results of 54 per cent Box; 23 per cent Merchantable and No. Two framing, and 23 per cent better grades (K. C. Chandler and I. G. Trotman, pers. comm.) The high cost of conversion has to be added to these indifferent results, the logs sawn to date have averaged between 7.3 and 11.7 in. s.e.d. (Tustin, 1968). Production costs in frame-mills double if six in. instead of 12 in. logs are sawn (Williams, 1956; Fenton and Brown, 1963). Further, the man-power involved in the production thinning of regime PR I is over 20 per cent of the total labour force involved.

Fundamentally inclusion of production thinning in management has been to:

(a) increase yields;

(b) obtain intermediate monetary returns;

(c) to allow greater selection of final crop stems.

Analysis of these three reasons follows.

Regime PR I gives a net yield of 11,600 cu.ft in 36 years; of this, 2,300 cu.ft - of pulp wood - comes from the thinning. The net M.A.I. (mean annual increment) is 314 cu.ft. Inclusion of an earlier production thinning prescribed by Rotorua Conservancy, but rejected in PR I would increase M.A.I. to 355 cu.ft. The prescription was rejected since only one area had been thinned with the following results: reduction of stocking to 116 s.p.a. compared with a prescription of 180; a yield of 3,000 cu.ft compared with a prescription of 1,100; and a cost to ride of 12.5c. per cu. ft.

A regime with no production thinning is given as PR II in Table 3-6, and the yields calculated in Appendix 6 give a net M.A.I. of 330 cu.ft , or 7½ per cent less than that of the full Rotorua Conservancy prescription. It is, however, far more likely to achieve its given stand densities. Undoubtedly, if periodic thinnings were made at the five to ten ft height intervals indicated for the United Kingdom, (Hummel and Christie, 1953) or at the five year interval adopted (on a basal-area regulation basis) in New South Wales (Lugton, 1968), yields could increase, but the 'second-crop' era of forestry has given little indication that these intensities are practicable in New Zealand.

Unfortunately, the advantage of intermediate revenue is easy to dispose of - operations to date have given minimal or negative returns (apart from returns from minor forest produce). The assumption of a net 3.75c. per cu.ft for the production thinning in PR I is considered optimistic. The contention that the cost of thinning plus a stumpage is paid by the utilization company ignores the place these costs may have in any subsequent stumpage revision.

Tree selection is probably improved by successive thinnings, but the degree of selection required has not been rationalised. Relative sawn-volume and value production by log-height classes are given in Table 3-7;

butt and second logs comprise half to two-thirds of the volume, and about 70 per cent of the gross value, of the final crop. The proportion depends on the final d.b.h./height ratio, being greater for young crops which have not produced large top-logs; for areas where height growth is limited (as in Hull's trees in the Wairarapa); and in intensively pruned stands. If only three saw-logs are taken per tree, and top logs are pulped, the proportion of value of the lowest two logs in pruned stands rises to 80 per cent of the gross value. If values net of full trimming and sawing cost are used, the results would probably be even more favourable to the two lowest logs and selection should largely concentrate on these. The only critical requirement for butt logs is straightness, and reasonable size, since the pruning schedule dominates other gross features; the real test is the second-log.

If second-logs are pruned, a large defect-core diameter inevitably results, core size being controlled by the stem diameter at the base of the pruning lift (Fenton, Sutton and Drewitt, 1963). The practical, as against the theoretical, core-diameter can now be calculated from further results from Waiotapu Cpt.28 (1).

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(1) A grade study of 26 year old 'second-crop' natural regeneration; the trees sawn averaged 23.4 in. d.b.h. and yielded five 18 ft sawlogs each.

The minimum core-diameter of 5.0 in. has to be increased 1.5 in. to allow for nodal swelling; the minimum diameter-over-stubs is 6.5 in. Further allowance has to be made for occlusion scars and for deviations in stem straightness, for which a further 3.5 in. diameter has to be added. The minimum-core is thus 10.0 in., and clear, full length boards may be anticipated after this. The intervening boards are Factory grade, and contain progressively fewer defects towards the outside of the logs. It appears more logical to concentrate on selection of Factory grade from this log-height class as the yield of Clears is not particularly high (Appendix 5) and Factory grade is independent of any subsequent treatment, as it depends on branch distribution, not on size or condition. A high proportion of this grade is produced by the branching pattern of radiata pine (Table 3-8).

Recovery of good board grades above the second log is greatly impaired by the frequency of stem cones and pin-knots; their relative occurrence is given in Table 3-9. Thinning of the stand will cause increase in branch size to over 1.3 in. (Sutton, 1968) and will be sufficient to prevent recovery of much No. One Framing. Overall, selection at 35-40 ft, and at 55 ft should concentrate on leaving final crop trees which can yield Factory grades in the second, and if possible, the third logs.

A summary of the forest regime for PR II is given in Appendix 7; establishment is concentrated into eleven years, initial spacing is rectangular, only butt logs are pruned, and growth is concentrated onto final crop stems by thinning; a high probable level of prescription-attainment is allowable, as there is no production thinning.

The management regimes for PR I and PR II are given in Chapter 9 with economic analyses.

Chapter 4 briefly enumerates the quality potential of species other than Douglas fir and radiata pine to see if any special qualities are available which are not present in the two major species.

TABLE 3 - 1 TIMBER GRADES OF FIRST-CROP RADIATA PINE - RESULTS FROM NON-INTEGRATED MILLS

	District				
	Rotorua		Canterbury	Southland[1]	
	1960	1965	1965	1960	1965
Annual cut, million bd. ft	22	22	0.4[2]	8	9
<u>Grades</u>, per cent of out-turn (3)					
Box	44	49	16	28	20
Merchantable	20	7	31	35	34
Dressing and better	5	2	5	6	8
Factory	5	5	½	8	6
Clear	0	0	0	0	0
No. One Framing	18	27	39	20	28
No. Two Framing	8	9	9	3	4

(1) 15 to 20 per cent of cut is of Corsican pine, which is not differentiated in the grade out-turn.

(2) Sample of 0.4 million bd.ft from a total annual cut of 3 million bd.ft.

(3) Figures may not add to 100 per cent due to production of non-standard grades (e.g. railway sleepers).

TABLE 3 - 2. TIMBER GRADES OF FIRST-CROP RADIATA PINE
- RESULTS FROM INTEGRATED MILLS

	Mill I		Mill II		Mill III	
	1960	1966	1961	1965	1962	1966
Annual cut, million bd. ft	64	84	50	78	10	14
<u>Grades</u>, per cent of out-turn (1)						
Box	61	51	18	25	41	39
Merchantable	6	4	14	12	13	32
Dressing and better	5	3	5	4	9	12
Factory	1½	4	5	11	2	2
Clear	0	0	4(2)		0	0
No. One Framing	22	30	28	34	26	19
No. Two Framing	5	8	13	14	9	5

(1) Figures may not add to 100 per cent due to production of non-standard grades.

(2) Clears are largely of shorts for finger-jointing; they are incorporated in Factory grade in later results.

Sources: direct data from the Companies.

TABLE 3 - 3 TIMBER GRADES OF FIRST-CROP RADIATA PINE - RESULTS FROM GRADE STUDIES

	Forest						
	Dusky (1)	Beaumont (2)		Kaingaroa (3)			
Spacing, ft	6x6	8x8		6x6(4)		8x8	
Thickness sawn(5)	1 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in
Volume sawn thousand bd.ft	14	41		89			
Grades, per cent of out-turn							
Box	40	52	39	61	34	57	44
Merchantable	30	23	7½	13	5	23	11
Dressing and better	12	5½	1½	1½	½	2	1
Factory	16½	17	0(6)	22	34	18	22
Clear	½	0	0	2½	2½	½	½
No. One Framing	0	2	28	0	15	0	13
No. Two Framing	0	½	23	0	8	0	8

(1) Fenton and Familton, 1961.

(2) Fenton, 1965a.

(3) Fenton, 1967b.

(4) The stand was belatedly 0/18 ft pruned.

(5) Other thicknesses may be sawn inevitably.

(6) Not graded in this study.

TABLE 3 - 4 TIMBER GRADES OF FIRST-CROP RADIATA PINE - RESULTS FROM PRUNED LOGS

Sawing Method	Vol. Sawn bd.ft	Timber grades - per cent (1) Box	Merch.	Dress.	Fact.	Clear No.1	Clear No.2	Remarks
<u>From</u> <u>Fenton</u>, <u>1967b</u> - Kaingaroa Cpt.1045								
Flat (2)	9,300	48	1½	2½	42	7½		Highest C.F.
Largely quarter(2)	8,600	25(3)	2	1	62	7½		
Taper (2)	7,200	37	2	1½	52	7½		Lower C.F.
<u>Hull's</u> <u>trees</u> - Butt logs (4)					(6)		(6)	
Largely flat	2,400	10	7	17	(26)	46	19	Brown,1965
	2,400	10	5	24	25	33	2	Regraded
Second logs (5)								
	2,400	12	18	22	(22)	33	15	Brown,1965
	2,400	21	11	18	24	24	2	Regraded
Whole tree results								
		17	24	19	(20)	30	10	Brown,1965
		24½	21	15	19	19	1½	Regraded

(1) No.2 Clears is clear on one face only; strictly interpreted it is equivalent to Merchantable grade.

Merch. = Merchantable; Dress. = Dressing and better; Fact. = Factory; C.F. = Conversion factor.

(2) Equal volumes of logs were sawn, the differences in bd.ft reflect conversion factors.

(3) Balance of timber - 2½ per cent - was of Framing.

(4) Only 10 logs were available for regrading, Brown's results have been adjusted accordingly.

(5) 12 logs were available from this log height class.

(6) Factory grade was not differentiated separately in Brown's results; nearly all No.2 Clear was Factory grade. The totals shown in brackets include Factory grade obtainable from Dressing grade.

TABLE 3 - 5 ASSESSMENT RESULTS FROM THINNED STANDS OF RADIATA PINE (1)

Forest	Age years	Top ht. ft	Stocking s.p.a. Prescribed From	to	Actual	Basal area sq.ft (2)	Equipment used
Whaka (3)	23	120+	250	80	48	83	D6 tractors
"	22	"	"	"	66	108	" "
"	20	110	"	"	62	89	" "
"	22	120	"	"	57(4)	85	" "
Kaingaroa(3)	15	70-85	5-800	180	133	90	TD6 "
"	15	"	"	"	116	67	" "
Ngaumu(5)	9	45	500+	250	173	47	Farm "
"	9	"	"	"	238	57	" "
"	10	"	"	"	239	75	" "
"	10	"	"	"	211	85	" "

(1) Source, Fenton, Mackintosh and Hosking, 1965.

(2) After thinning.

(3) Tree length pulpwood extracted.

(4) The stand also contained six eucalypts per acre of 16 sq. ft basal area, in addition to the radiata pine stocking shown.

(5) Fence posts extracted; wheeled tractors used.

TABLE 3 - 6 RADIATA PINE TENDING REGIMES

Operation		PR I s.p.a.	PR I Top ht. ft	PR I Age years	PR II s.p.a.	PR II Top ht. ft	PR II Age years
Establishment		900	-	-	620	-	-
Pruning	0/8 ft	3-400	16-18	4-5	300	16-18	4-5
	8/14	180	28	6	150	28	6
	14/20	150	35-40	8-9	90	35	8
	20/28	60-80	45	10			
	28/36	60-80	55	12			
Thinning to waste							
First		220	45	10	150	35-40	8-9*
Second					80	55	12
Production Thinning							
		80	90	18			
Clearfelling							
		80	140	36	80	120	25-26

* If minor forest produce is required 500 cu.ft of 6 ft x 6 in. diameter material is available.

TABLE 3 - 7 TIMBER PER LOG-HEIGHT CLASS (18 ft LOGS)

Forest	Per cent out turn by log-height class									
	Butt		Second		Third		Fourth		Fifth	
	Vol.	Val.	Vol.	Val.	Vol.	Val.	Vol.	Val.	Vol.	Val.
Kaingaroa Cpt.1045(1)	31	37	25	24	20	18	16	13	8	7
1061(1)	32	32	26	28	20	20	14	$13\frac{1}{2}$	8	$7\frac{1}{2}$
Waiotapu Cpt. 28(2)	32	40	29	28	19	$16\frac{1}{2}$	14	$10\frac{1}{2}$	6	5
Hull's Trees (3)	$35\frac{1}{2}$	$30\frac{1}{2}$	28	$30\frac{1}{2}$	20	$16\frac{1}{2}$	13	9	3	2
Dusky Cpt. 9(4)	30	N.A.	26		20		16		9	

Vol. = volume; val. = value.

(1) Fenton, 1967b.

(2) Study by Fenton, Sutton and Tustin, 1968, publication in preparation.

(3) Fenton, 1968a.

(4) Fenton and Familton,1961.

TABLE 3 - 8 PROPORTION OF FACTORY GRADE BY LOG-HEIGHT CLASS

Forest	Per cent out turn by log-height class				
	Butt	Second	Third	Fourth	Fifth
Kaingaroa Cpt.1045 (1)	Pruned	24	13	5	3
1061 (1)	21 (4)	29	14	9	6
Waiotapu Cpt. 28 (2)	Pruned	34	12	4	0
Dusky Cpt. 9 (3)	30 (4)	21½	11½	1	1½

(1) Fenton, 1967b.

(2) Study by Fenton, Sutton and Tustin, 1968, publication in preparation.

(3) Fenton and Familton, 1961.

(4) Belatedly 0/7 pruned.

TABLE 3 - 9 FREQUENCY OF SMALL BARK-ENCASED (PIN) KNOTS, AND CONE-HOLES IN RADIATA PINE

Forest	Number per 100 bd.ft of timber sawn			
	Log height-class			
	Second	Third	Fourth	Fifth
Small bark-encased knots				
Kaingaroa Cpt.1045 (1)	17½	26½	32	37
Cpt.1061 (1)	20½	27	32	32
Waiotapu Cpt. 28 (2)	11	13½	10½	8
Hull's trees (3)	-(4)	14(4)	30½	29
Cone holes				
Kaingaroa Cpt.1045 (1)	1	8	19	47
Cpt.1061 (1)	3½	16	29½	46
Waiotapu Cpt. 28 (2)	1	7	24	67
Hull's trees (3)	-(4)	12(4)	40½	126

(1) Fenton, 1967b.

(2) Study by Fenton, Sutton and Tustin, 1968, publication in preparation.

(3) Fenton, 1968a.

(4) Trees well pruned to half-way up third log.

CHAPTER 4 - UTILIZATION POTENTIAL OF 'FIRST-CROP' STANDS OF OTHER THAN RADIATA PINE AND DOUGLAS FIR

Species other than radiata pine and Douglas fir occupy 220,000 acres, and although not recently planted on any scale, represent a considerable 'first-crop' resource. These extensive and largely old (35 years or older) stands should have a complementary function to the two major species.

Corsican pine is the best of the other species. The timber qualities have been assessed (Fenton, 1960) in studies which were confirmed by sawmill experience. Briefly, degrade through bark encasement of the knots greatly affects board grades but good grades of framing can be sawn due to the smaller size of branches compared with radiata pine. Summarised grade figures are given in Table 4-1. Advantages of Corsican over radiata pine include a smaller core of low density and pith-affected wood; great regularity of branch production in annual whorls; the absence of stem cones; and a fairly high yield of good grade framing material - at least in the unseasoned condition. Its disadvantages include a slower growth-rate - which does not result in any compensatory increase in density or better finishing quality; and the resulting smaller log-size - with greater costs of production. Export potential lines include short clears for finger-jointing - usually two feet long but from 15 to 30 inches depending on the site quality ; framing timber; and to a limited extent, boards for flooring or panelling. Corsican pine boards resemble those of cypress pine, without of course, possessing the natural durability of the latter; if Corsican pine is preservative treated and dried it may find acceptance as a substitute for cypress pine. The New Zealand supply of panelling would be practically limited to boards from top logs or correctly treated younger stands. Corsican pine produces little that is not produced more rapidly from radiata pine, but its timber qualities are, at least, similar to the major species. Austrian pine is of very poor quality and will form no part of either future afforestation or exports.

The extent of the ponderosa pine resource is impressive, but large areas are of poor inland provenances of British Columbian origin. The silvicultural and timber characteristics of the species have been given elsewhere (Hinds and Reid, 1957). It has better kiln-seasoning characteristics as boards than radiata pine, since the knots do not check as badly; about 20,000 cu.ft of logs per year at Conical Hill mill, supplemented by results from Naseby forest, showed its board grade characteristics are similar to those of Corsican pine. There are no grounds for assuming special timber qualities from this extensive resource. N.Z. Forest Products Ltd., who own integrated saw-and pulp-mills, are converting such areas of ponderosa pine that they planted with little attempt at utilization - alternate rows are crushed, or all trees are crushed and burnt. The scopulorum variety is too small, after 40 years, to provide more than minor produce.

Lodgepole pine has also been planted extensively but about half of the areas planted are of poor provenances. The grade prospects are promising from the 'green' strains and the results included in Table 4-1 reflect the relatively young age of the stand studied. The absence of stem cones has to be set against the characteristically heavy branch whorls, which produce both critical cross-section defects and grain-distortion in framing. Undoubtedly the species should technically be grown on short rotations to produce good grades of knotty boards above one pruned log. As with Corsican and ponderosa pines, the regularity of branch whorl production could lead to increased utilization by finger-jointing. The area planted with lodgepole pine is likely to increase to a significant amount by year 2000 as a higher proportion of severe sites (either frosty or excessively wet) are afforested and because of the short rotation necessary. (All three of the pines discussed above are suitable for both groundwood and chemical pulp, although Corsican pine heart and branchwood is resinous and restricts input of this species).

The only other species with any likelihood of future potential are the Southern pines. Slash pine has low, uniform density and will continue to be planted in the north of the North Island because of its greater tolerance of poorer soils than radiata pine. The limited data on timber grade and seasoning (J.A. Kininmonth, pers. comm.) show poor results on the small samples studied to date. Patula pine will be a possible species, if only because of its resistance to *Dothistroma*. All the Southern pines need particularly careful pruning if sawn timber is the aim of silviculture; technically they will be difficult to grow since although pruned wood will be of good quality, the logs above the pruned zone will be very poor, because the encased knot defects of the dead branches are compounded by rot and large bark pockets. Loblolly and longleaf pines are unlikely to be widely planted in future, partly owing to these defects.

The stands of muricata and pinaster pines in New Zealand are of very poor quality and these species only offer grades produced by other species.

The only other conifer of any economic importance, apart from Douglas fir, is European larch. Its timber has the limitations of Douglas fir as boards, but lacks the dimensional stability as framing (Fenton, 1967a). The high strength properties of larch enable it to be exported in limited quantities for tile battens. The increment rate of larch is amongst the lowest of exotic conifers and contrary to earlier reports (Weston, 1957), it is not being established on any scale.

In summary, the 220,000 acres of species other than radiata pine or Douglas fir have little to offer in either superior, or complementary timber qualities. The Corsican, ponderosa and lodgepole pines comprising two-thirds of this area can yield higher proportions of short clears for finger-jointing than radiata pine; they can all be pulped if necessary, and may also produce small quantities of knotty panelling. Corsican and ponderosa pine framing is generally good grade when green, because of the small knot size; but their ability to season without distortion has not been tested. Only lodgepole and slash pines are likely to be planted in future.

Lodgepole can tolerate harsher sites (colder and wetter) than radiata pine; or Douglas fir; slash pine tolerates nutrient deficient northern sites unsuitable (without treatment) for radiata pine.

TABLE 4 - 1 GRADE RESULTS FROM CORSICAN, LODGEPOLE PONDEROSA AND SLASH PINES

	Age years	Top ht ft	Volume sawn bd.ft	Grades (per cent) Box	Merch antable	Dress ing	No.1F	No.2F	Factory
	Corsican pine								
(1)	52	75	3100	52	24	23	-	-	-
(2)	52	75	3100	19	2½	6½	65	6	-
(3)	30	51	5000	12	9	3	43	16	-
	Lodgepole pine								
(4)	33	70	3500	12	23	32	21	10	-
	Ponderosa pine								
(5)	Southland sawmill			37	28	30	-	-	5
(6)	intake			6	3	10	65	13	3
	Slash pine								
(7)	(Balance Clear)			52	18	5			21
(8)				24	-	-	42	34	-

(1) Fenton, 1960 - sawing to 1 in. boards; Southland

(2) Fenton, 1960 - sawing largely to 2 in. timber; Southland

(3) Unpublished results - Karioi Forest, sawn largely to 2 in; 18 per cent of timber was of shorts and was not graded

(4) Familton, 1962; Karioi Forest; butt and second logs only

(5) 1 in. cutting. Unpublished results, Conical Hill Mill

(6) 2 in. cutting. Unpublished results, Conical Hill Mill

(7) 1 in. cutting. Pruned stand, Tairua, Auckland Conservancy data

(8) 2 in. cutting. Pruned stand, Tairua, Auckland Conservancy data

PART II. PROFITABILITY ANALYSES

CHAPTER 5 - PROFITABILITY CRITERIA IN RELATION TO FORESTRY

This and the subsequent four Chapters comprise the primarily economic section of the study. Profitability criteria are examined here, and interest rates are discussed in Chapter 6. Secondary economic effects are analysed in Chapter 7; detailed analyses of Douglas fir and radiata pine regimes are made in Chapters 8 and 9.

(a) THE CRITERIA OF MAXIMUM PRODUCTION AND FOREST RENT

The earliest theories governing forest production included those formulated in Germany in the late eighteenth and early nineteenth centuries, and initially were aimed at the production of maximum volume from the site. A modification was the production of maximum monetary yield. They arose partly from the then indispensible nature of many forest products, and partly as an outgrowth of mercantilist philosophy, with stress on national self-sufficiency (Thomson, 1942). As originally developed, the theory of maximum volume production ignored both the capital involved and even the current costs of production of forestry.

The less extreme concept of forest rent evolved in Germany in the mid-nineteenth century, and it aims at maximising annual monetary yields, after allowing for the direct costs of production. It is also refutable since it ignores the interest payable on the capital invested in the forest (Hiley, 1930; Gaffney, 1960). Despite their lack of economic validity, both the theory of maximum production (of either volume or money) and of forest rent are still widely held by foresters (Barnett and Morse, 1963) and 'exert a deep influence on forest policy' (Hiley, 1956). Petrini (1953), in a standard European textbook on forest economics, effectively refuted the theories, but later stated 'it is a primary requirement that the forest unit should furnish the largest possible quantity of timber so that the productive capacity of the site may be fully utilised...(and)...only very special reasons can justify any departure from this fundamental principle' Another Swedish authority stated 'that the Forest Service is expected to manage forests for the highest income in money on a sustained yield basis' but made the qualification that it was never intended that capital investment should be so high that marginal returns on the investment would be nil (Streyffert, 1960). A contradiction is then made by support for a Swedish pulp and paper company president: 'whose views on forestry objectives may be taken as representative of the Swedish forest industry (and whose views) could as well... been made by a representative of the Government'; these views were: 'Let us aim at the highest possible yields from our forests, irrespective of the species, but with some regard to the quality of the timber'. (Streyffert, op. cit.) The ambivalence is characteristic, and this Swedish policy has been criticised on the grounds there is no certainty the costs incurred through maximisation of volume production are more than matched by the additional net earnings gained by processing higher volume (Grayson, 1962).

The United States Forest Service is required to set rotations on technical, rather than on economic grounds and 'often feels that on the national forests there are sound reasons of public policy for growing quality sawlogs in an area as a major product even though pulpwood is the most common and possibly the most profitable major product' (Davis, 1954). The United States Forest Service bases rotations on the criterion of maximum volume production (Bentley and Teegaurden, 1965; Gaffney, 1960), and its projections of future requirements are based on physical targets (U.S. For. Serv., 1958) and assume in effect 'that timber supply is highly elastic with price' (Duerr,1960).

In the Soviet Union, where national ideology rejects much of classical economics, forest policy is also set by theories of maximum physical production (Kostiukovich, 1964). (The economically indefensible pay-off period - though not often employed in forestry - has been widely used in other fields in the U.S.A. and the U.S.S.R., Turvey, 1963). The similarity of forest policy in countries of strongly contrasting political ideology is completed by the example of Germany where the Nazi government banned short (viz. economic) rotations in 1934 (Gaffney, 1960; Thomson, 1942). The attitudes of other European forest authorities are similar; a leading British forester stated: 'The main aim of sound forest management is, of course, to bring the forest to the highest possible level of production and to ensure that such production is maintained' (Anderson, 1953). In Switzerland the State is considered to have a responsibility to provide the larger trees 'demanded by industry ... even if their production (is) less profitable than the production of smaller sizes' (Knuchel, 1953). Similarly, the national forestry statements presented to the seventh and eighth British Commonwealth Forestry Conferences showed that while autarchy was an aim of policy in most countries, only in Uganda and, since 1962, in Great Britain, were other economic criteria formally specified.

A leader of the Conservationist movement in the U.S.A. - G. Pinchot - is quoted (in Barnett and Morse, 1963): 'the five indispensably essential materials in our civilisation are wood, water, coal, iron and agricultural products ... we have [in 1910] timber for less than 30 years at the present rate of cutting'. (Certainly wood and coal are now far from indispensable, the position of iron and agricultural products is more debatable, and only water is, perhaps, indispensable). The underlying motivation of maximum production is Malthusian and derives from traditional European concepts of the indispensable nature of local forest products (Barnett and Morse, op. cit.), an idea outmoded by the lowered transport costs of the last century and by the substitution possible with current technology. Direct forest products are not indispensable and while the utility of forests for protective or recreational uses could be considered in the context of their being public goods, the use of production forests for direct benefits of timber, pulp and other products cannot claim any special treatment, as these products are neither necessarily profitless nor essential. Production forestry, like other economic activities, ultimately exists to satisfy purposes of consumption and hence is covered by the existing tenets of economics.

The attitudes exemplified by the foregoing examples take little cognizance of the cost of production and originate in part from the historical development of forestry in Europe and in North America and in part from the peculiarities of forestry itself. These peculiarities are not individually unique, but their combination illustrates why theories of investment decision are still so open in forestry, they are:

(i) The nature of production of managed forests is highly capitalised, and has a high capital/yield ratio.

(ii) The majority of the capital is represented by the trees themselves, which are also the means of production; these can, over a wide time range, be liquidated if required and do not necessarily deteriorate with age.

(iii) The appropriate price level and demand, for <u>reproducible</u> forest products, remains unknown, as the majority of wood supplies still come from relatively cheap natural forests and bear only the costs of exploitation.

(iv) Within individual countries, forests and utilization plants may be of mixed State or private ownership; the owners may adopt different methods of measuring profit.

(v) The capital investment profile (1) is irregular in many forest regimes, which makes analysis more onerous than allowing for regular events by the use of formulae. This should not be a real difficulty, but has discouraged analysis in practice.

(vi) Possibly the most insidious effect of the long time interval between investment and harvest has been evasion of responsibility for results. Incentive for economic management has been difficult to provide.

(vii) A marked trend towards vertical integration (2) is occurring, and makes a choice of any given horizontal sector, such as growing the trees, artificial for analytical purposes.

Points (iii) to (vii), while obvious enough, are infrequently recognised as pecularities of forestry, but the effect of tending to maximize volume production rather than to manage a forest business, is of profound importance.

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(1) The 'profile' of an investment in the economic sense is given by the costs and returns through time, in forestry time is usually measured in years.

(2) 'Vertical integration': the extension of an organisation's activities throughout the range of operations involved in placing a final product on the market; in the case of forestry the traditional divisions - or horizontal sectors - have normally been growing the tree crop; in primary utilization in a pulp or sawmill; and in marketing the mill products.

(b) THE FAUSTMANN FORMULA AND ITS DERIVATIVES

The adoption of the goal of maximum wood growth on a sustained yield basis has been, of course, criticised within forestry itself, and its adoption for example in large wood-using corporations in the U.S.A. 'implies a most desperate supply position with regard to both wood and land' (Fedkiw, 1960). The most generally used method of assessing profitability in forestry is by use of the Faustmann formula, which again originated in Germany in the mid-nineteenth century. In principle it allows for the differences in time over which costs are incurred, or returns obtained by compounding (or discounting) and then at a constant point in time - usually the beginning of the rotation - assessing the results. It is frequently solved for land expectation values (L.E.V.) (viz. present net worth per unit area), using given interest rates, whereby comparisons can be made of the relative profitability of different species or silvicultural regimes by the difference in price paid for the land. The formula can also be solved to find the internal rate of return (I.R.R.) or to find the present net worth (P.N.W.) after allowing for the cost of land. The approach has been tested in full theoretical analysis (Gaffney, 1960) and in a simpler graphical analysis (Bentley and Teegaurden, 1965) and is theoretically sound; it has been frequently used in practice (e.g. Anon, 1966a; Chisholm, 1963); and is described in fundamental forestry economics texts. A similar form has been suggested for use in analysis of agricultural economics (Philpott, 1961).

The solution to yield the net discounted revenue per unit of invested capital, that is the discounted value of future returns up to a given period divided by the discounted costs up to the time when the project becomes self-financing, has been used to facilitate comparisons between forestry and other investments (Anon, 1966a; Sinden, 1964).

In criteria outside forestry which accommodate the cost of capital claims have gone so far as:

> 'Investment decision making has probably benefited more from the development of analytical decision making methods than any other management area. In the past ten or fifteen years increasingly sophisticated methods have become available for analysing investment decisions. Perhaps the most widely known of these new developments are the analytical methods that take into account the time value of money. Those include the net present value method, the discounted cash flow method and variations of these techniques' (Hespos and Strassman, 1965).

Outside forestry the adoption of discounted cash flows was considered to be 'a significant step forward' (Henderson, 1965), although in general business decisions they have not been used more 'as most decision-makers are not trained to do so. In many cases they have been over-exposed to accounting tradition and the whole idea of discounting may be against the grain' (Wright, 1964). The principle of compounding values has been accepted in forestry for at least a century, Thomson (1942) instanced its recommended use by Pfeil in 1822.

The shortcomings of solving the Faustmann formula for the I.R.R. are examined in the next section, and the more recent developments of cost/benefit analysis and P.N.W. (viz. L.E.V. x Area for forestry) then follow before final consideration of the most useful method of analysis to be adopted in analysing plantation forestry.

(c) THE INTERNAL RATE OF RETURN (I.R.R.)

Apart from Webster (1965) there has been relatively little reflection in forestry of the economic debate over the relative advantages of the I.R.R.,and of the P.N.W. and its derived techniques in determining profit. The controversy has been termed 'a pivotal point of capital theory' (Wright, 1964). When a number of projects are compared, the I.R.R. on capital invested is used to rank them in order of relative profitability. Under conditions of capital rationing, which in practice applies to much government investment, the projects are ranked downwards until the budget allocation is used. When no capital rationing exists, investment proceeds until the marginal rate of return equals the market rate of money. In the latter case the I.R.R. is in effect the marginal efficiency of capital (Keynes, 1936), a concept developed in forestry as forest financial maturity (Duerr, Fedkiw and Guttenberg, 1956). As such, it excludes consideration of land cost and is applicable for only one rotation (Bentley and Teegaurden, 1965) and so is less general than the Faustmann formula. The use of I.R.R. has been called 'frequent' (Massé, 1962) and it has been used, for example, in oil company decision-making for rather widely differing types of investment, where its use has been found 'meaningful in relation to those used through the financial world... it permits direct comparison of the projected returns... with the cost of borrowing money' (McLean, 1958).

As a practical measure, the time streams (1) and capital profiles(2) of the ranked projects should also

(1) Time stream of an investment - in effect its budget over time, normally expressed in years.

(2) Capital profile - the inputs of capital required over time, normally expressed in years.

be specified with allowance for more than one time horizon (McKean, 1958). On the theoretical side the use of I.R.R. has been preferred to any given external rate as 'there is no persuasive evidence that x% is right, and no operational method for determining it' (McKean, op. cit.). The variations in external interest rates are accommodated only by assuming 'that the degree of capital rationing, and the outlook for investment opportunities will continue to be the same in future years' (McKean, op. cit.), a view that has been contested (Feldstein, 1964; Bailey, 1959).

The three major objections to the use of I.R.R. are:

(i) Sources of investment funds and alternative investment opportunities are only rarely available at the rate of I.R.R. (Hirshleifer, 1958; Turvey, 1963; Feldstein and Fleming, 1964).

(ii) In comparison with the ruling external rate, the use of I.R.R. can give non-optimal ranking of alternatives (Henderson, 1965).

(iii) With polynomial functions there may be no unique solution for the rate, with up to as many roots as there are years in the programme (Feldstein and Fleming, 1964; Massé, 1962).

The difference between the I.R.R. and the external rate leading to non-optimal results was accepted by McKean (1958), who pointed out that when for example, the I.R.R. of two alternatives are both below the ruling rate, decisions have to be made at sub-optimal levels. The third point - of potential multiple solutions - is of more importance in forestry, as the use of the I.R.R. by solving the Faustmann formula for 'financial yield' has been a major method of ranking alternatives (Hiley, 1956). The lack of a unique solution has already been simply resolved in empirical studies 'by noting the direction of change in the present worths as higher discount rates are introduced in trial and error calculation ' (McLean, 1958). Where only one change in sign occurs unique solutions are usually found empirically (Ward, 1964a) and this special case has been shown to be theoretically valid (Teichroen et al., 1965). The I.R.R. can therefore give rational results to forestry problems, though the theoretical objections (i) and (ii) remain. In practice, a more formidable objection in some cases is the insensitivity of the I.R.R. as a practical indicator in forestry. A difference of less than half a per cent in I.R.R. value would be an inconclusive reason for adopting an alternative in forestry, since the costs and returns involved in any calculation are often not known with certainty, or are themselves subject to error.

(d) THE PRESENT NET WORTH (P.N.W.) AND COST/BENEFIT (C-B) RATIOS (1)

The P.N.W. of a project is found by discounting returns, net of costs, at given rates of interest; in forestry, the P.N.W. is traditionally divided by the area, thus becoming the land expectation value (L.E.V.). The P.N.W. can be expressed per unit of capital, when the capital is taken up to the point where the project is financially self-supporting. The C-B ratio criterion expresses the capital costs directly, as well as allowing for discounted returns. All these methods are used, and appear to be those most favoured by economists (Boulding et al.,1960), partly as more limiting assumptions are needed for I.R.R. than for P.N.W. (Toren, 1961). The P.N.W. has even been referred to as the universally correct criterion (Alchian, 1955). Use of the P.N.W. has

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(1) Although benefit-cost is probably more apposite, cost-benefit has been used here as it appears to be favoured by the majority of authorities. Cost-benefit ratios are discussed here; the concept of cost-benefit analysis has a wider connotation (Ward, 1968; Leslie, 1967) and includes externalities. These are discussed, but not evaluated, in Chapter 7.

been recommended in agriculture (e.g. Philpott, 1961; Ward, 1964a); the L.E.V. has been used in forestry (e.g. Lugton, 1968; Chisholm, 1963; Walker, 1960); the use of P.N.W. per unit of capital has been used in land economics (Anon, 1966a) and in forestry (Sinden, 1964); and the application of C-B ratios has been extensively developed in the evaluation of large-scale water-resource schemes (Eckstein, 1961; Krutilla and Eckstein, 1958) where their use is obligatory for projects requiring federal financial assistance in the U.S.A. (Ward, 1964a). C-B ratios have also been used in land development planning (Bur. Ag. Econ., 1963). The P.N.W. criterion can yield anomalous results whereby an increase in the rate of interest can apparently improve, rather than detract from, the worth of an investment. This occurs in sub-optimisation calculations where the P.N.W. is negative and where the initial sum in a time stream is negative and subsequent ones positive; the negative P.N.W. can decrease with a rise in interest rates. A simplified empirical demonstration, using figures of the relative order of magnitude for pulpmill investment, is shown in Table 5-1; the P.N.W. at 10 per cent is not as low as at 7 per cent for some income levels. As negative L.E.V.s have been used in forestry texts as legitimate ranking methods (viz. Hiley, 1956), the qualification could occasionally be of practical importance, as the figures used in Table 5-1 are feasible for current forestry investment. The theoretical implications are considerable in limiting the universality of the P.N.W. and related criteria. In forestry practice it means the direction of change of P.N.W. with increase or decrease of interest rate should be known if P.N.W. values are negative.

Where there is no capital rationing and where projects do not differ markedly in either degree of risk or capital intensity, it has been suggested projects should be adopted so long as the net benefits are not exceeded by the costs (Eckstein, 1961). Where capital rationing applies, a cut-off point for C-B ratios would limit the number of projects (Eckstein, op.cit.). Similar proposals were made for public investments in the United Kingdom (Henderson, 1965).

The major criticism of this principle, and its derivatives, is whether an external interest rate is a proper criterion; choice of a low interest rate and a high shut-off C-B ratio can give different results to the adoption of high interest rates and a low shut-off point. The relative neglect of the principle in forestry is surprising, since by appropriate choice of rates and shut-off points, the effect of compound interest charges could be reduced - but there are no clear objective grounds for adopting this procedure. Apparently it presents a device for circumventing rather than accounting for the effects of interest rates. A further criticism has been that C-B ratios could be used outside the contexts defined by Eckstein (McKean, 1958), as in practice the projects concerned could be dissimilar in scale or degree of risk. This criticism could equally apply to other criteria, as could McKean's further objections that C-B ratios used alone ignore the absolute scale of costs and returns. More importantly, C-B ratios do not necessarily give the right results in evaluating projects which differ in their annual costs, as a project with a high gross return and high operating costs is at a disadvantage compared with one with smaller annual charges and returns, whatever their contributions to net worth (McKean, op. cit.). Discrepancies between the various methods have been considered to be much less worrying than discrepancies in the assumed cost and return data (Toren, 1961). A large-scale empirical study of the effects of different rating systems on a range of forest management proposals, using C-B ratios, P.N.W. and the I.R.R. criteria, among others, showed few important differences in the final rankings (Webster, 1965). The results of this study were surprising in that the rates of interest chosen were three and six per cent, yet the P.N.W. at both these rates, and the I.R.R., gave similar rankings of alternatives. Again,

> '...that in relation to each method of estimating the opportunity cost of a public investment project, there is considerable scope for disagreement on formal and on empirical matters. Thus it is quite possible for two estimates of the opportunity cost of a given project arrived at independently by two disinterested and well informed observers to differ by a factor of two or more' (Henderson, 1965).

(Henderson mentions that observers are rarely disinterested, and often not well informed.)

Discussing the P.N.W. and I.R.R. criteria for use by business managers, Wright (1964) concluded 'in some situations, these two techniques can yield conflicting conclusions...This discrepancy need not concern us too greatly as neither system is overwhelmingly popular in practice. (sic) In any case the likelihood of conflicting conclusions is the exception rather than the rule.'

Stoevener and Castle (1965) consider that 'because a benefit-cost ratio of unity has come to be regarded as a necessary condition...for a project, in practice benefit-cost has been subjected to great pressure so that as few projects as possible would be eliminated on that basis.' Another example reported ratios of 1.2 and 0.13 for the same project (Prest and Turvey, 1965). Concern for the detail of a project should presumably then be of more interest than the particular method of analysis.

Turvey (1963) has indicated arguments about criteria depend on what is to be maximised and the relevant constraints, and the arguments should be about these and not the criteria. The choice of maximands and constraints involve value judgements (Turvey, op. cit.) and these are considered under interest rate in the following Chapter.

TABLE 5 - 1

CHANGES IN P.N.W. WITH INTEREST RATE

($)

		Interest rate per cent (1)		
COSTS				
Annual		4	7	10
2.35 p.a. capitalises to		58.75	33.57	23.50
Utilization plant, year 22 cost 200.8		84.73	45.32	24.66
Intermediate costs				
Amount	year			
9	1	8.65	8.41	8.18
5	2	4.62	4.36	4.13
3	3	2.66	2.44	2.25
1	21	0.43	0.24	0.13
TOTAL COSTS (2)		159.8	94.3	62.8
RETURNS				
A - Income 11.6/year at year 22				
Discounted (3)		122.3	37.4	14.2
P.N.W. (2) - (3)		-37.5	-56.9	-48.6
B - Income 16.0/year at year 22				
Discounted (4)		168.8	51.6	19.6
P.N.W. (2) - (4)		9.0	-42.7	-43.2
C - Income 34.4/year at year 22				
Discounted (5)		362.9	110.9	42.2
P.N.W. (2) - (5)		203.1	16.6	-20.6

(1) Discounted totals in year one

CHAPTER 6 - THE RATE OF INTEREST

(a) FACTORS AFFECTING INTEREST RATES

A decision on the rate of interest is fundamental in assessing profitability, whichever criteria are used. When this decision is made, differences between profitability criteria depend on interpretation of cost and revenue flows. Acceptance of an external or 'reasonable rate' of interest is required by the P.N.W. and associated methods, whereas the calculation of the I.R.R. may not necessarily be accompanied by comparisons with external rates.

Interest fundamentally exists to ration, allot and reward capital. If returns are deferred, the interest foregone accumulates a charge if investment alternatives exist. The interest charge contains several components. The minimum represents 'pure' cost, which is the rate chargeable on riskless enterprises, assuming money values remain unaltered and there is complete capital liquidity. The lowest general rates of return on investments are from readily negotiable government securities, with their relative absence of risk (although in the Weimar republic, for example, these were made valueless).
In the U.S.A. and the U.K. this rate moved over only a restricted range for long periods of the nineteenth century when returns on British Consols averaged

3.28 per cent (Guttenberg, 1950; Keynes, 1936). Since the 1939-45 war and the subsequent expansion of the economy, increased rates apply in the United Kingdom as 'the modern six per cent norm compared with the old nineteenth century three per cent Consols is itself justified by the degree of inflation creep' (Anon, 1966b). If inflation is incorporated by adjusting the fundamental rate, there is a danger only its cost and not its 'benefits' will be accommodated. Use of a higher interest rate to allow for inflation must be accompanied by adjusted costs and prices throughout the period of analysis. Constant costs and prices are simpler to use than a higher, inflation rate of interest. (There may, of course, be other reasons for altering cost, return and interest elements.)

Price changes themselves follow changes in interest rates 'as the rate of (external) interest changes, the structure of price changes, especially the ratio of present prices to future prices' (Alchian, 1955). Another effect of time which tends to increase the rate of interest for long term investments in an economy where the real standard of living is rising is 'as consumption per head increases, each absolute addition to it will yield successively smaller increases in economic welfare' (Henderson, 1965). It follows that higher interest rates are applicable where national growth rates are high (Eckstein, 1961). These effects are usually overlooked in forestry.

An allowance for risk may have to be added to the pure rate as a premium to allow for loss of income; this premium would rise with increases in the duration of the project due to increasing uncertainty. Long term investments have been considered to justify lower interest rates than short term investments: 'when due consideration is given to the risks involved, a three or four per cent rate of return is somewhat comparable to a five or six per cent one of short term' (Guttenberg, 1950), but such an attitude is unusual and bears no relation to the market rates of either Government loans, or of company debenture securities. Forestry is not a risk-free enterprise and allowance for risks and uncertainty must be made. Risks are occurrences whose likelihood can be calculated from past experience; they may be physical, as by loss through fire and natural agencies, or more debatably, managerial, such as failing to obtain labour and other inputs when required. The effect of changes in product values over time - whether by inflation or other causes - has been called risk (Duerr, 1960), though their calculability is doubtful.

Uncertainties arise where technical knowledge and experience are limited, as in much of plantation forestry. The method of adjustment for calculated risk can be via the interest rate or through altering costs and prices.

Guttenberg (1950), recommended that Fisher's (1930) method be used, viz:

$$\text{Net interest rate, including risk} = \frac{\text{pure rate}}{\text{1 minus chance of loss}}$$

so if the chance of loss is 1 in 5, or 0.2, then the net interest rate, for a pure rate of 2 per cent is $2 \div 0.8 = 2.5$ per cent. Such an adjustment would have to be used carefully where the effects of separate calculable risks are involved, as they are not necessarily additive. In a forestry example there may be a 1 in 5 risk of loss by fire and an equal risk through, say, insect attack. If these are added the interest rate above of two per cent increases to $3\frac{1}{3}$ per cent but if calculated sequentially, as in this case they should be, the net rate is $3\frac{1}{8}$ per cent. Actual fire losses are low, and have averaged less than 0.1 per cent annually of the established area in State plantations over the last 20 years (Appendix 8), and even if this percentage adjustment is made, allowance for salvaged material would be required. Fire losses are better allowed for by fully costing the protection charges and, if necessary, by subtracting a physical volume of wood lost. Similarly biological risks can be better accommodated by reducing physical yields rather than by altering interest rates.

The other method of allowing for risks has been by raising costs on an overall percentage basis (Webster, 1960; Vaux, 1954) while keeping the interest rate constant. Such a flat increase is illogical if some costs are known reasonably accurately. Thus to increase well-known establishment costs by 25 per cent (Vaux, op. cit.) because of, for example, problematical future thinning costs, has a disproportionate effect on the final results. It would be better to prepare a 'best estimate' of costs, and to prepare further sets of results incorporating the range of likely figures (Dowdle, 1962) if the unknown costs are thought to be very different. Similarly, changes in product prices are best accommodated by separate calculations of their effects, rather than by assuming one reduced price level.

Generally the question of risk has been too conveniently dealt with in forestry analyses by following the understandable tendency to simplify and not take account of details. The overall adjustments to either interest rates, or constituent cost or return elements appear reasonable at first sight, but due to the formidable effect of interest charges, can have undue effect on the final results. These differential effects are demonstrated for the PR II regime in Chapter 9.

The third component of the interest rate is the allowance for profit. The slow response of investment to long-term projects can only be resolved, in classical terms, by a sufficient rise in their apparent profitability (however measured) to attract capital. Governments must ensure future supplies of public goods (such as water and, more debatably, power and communications) are provided by adequate current investment. The problem still remains of the best way of meeting the demand (for fulfilling power demand for example by a few large or many small hydro-electric stations, by steam plants or atomic-fuelled generators); the choice is influenced by the method of analysis adopted. As research into investment criteria has developed, a distinction between the social time preference of different classes of investors has been made; and a further distinction has been made between these social time preferences and the opportunity cost available to capital elsewhere. The social time preference will be at the highest rates for individuals who want their rewards before they die; it decreases with increasing size of the firm until, for large corporations it is relatively low, and should be least for the government. The social time preference of small forest owners in the U.S.A., for example, has generally been too high to support forestry (Duerr, 1960); and rates of 12, six and three per cent were used to evaluate the preceding three classes of owners there (Anon, 1963a). When social time preference rates are used, and even if individual time preference is rejected for public decision-making, opportunity cost, including foregone consumption, is considered to be a critical parameter which must be incorporated in the model (Eckstein, 1958). Alternatively, for public investment decisions it has been proposed that the market-determined evaluation of future consumption may be rejected in favour of a politically determined rate, and an individual's time preference contrasted with society's (Feldstein, 1964).

The maximum rate which the government should bear was considered in discussing the financing of French power projects:

> 'if the equilibrium interest rate is going to increase for a long period, the government would, in my (Boiteux's) opinion, be compelled to resort to forced saving. The rate of discount, which assumes the equilibrium of the supply and demand for capital, is closely related to the amount of income which consumers are willing to save. A high rate of interest reflects... unwillingness to save for the future. Such negligence may well appear to be reprehensible on a national scale. The government would therefore have to offset the national behaviour of individuals on the assumption that they are doubtless adults in dealing with the immediate problems of life, but minors with respect to decisions involving their future, or their posterity.' (Boiteux, 1964).

Again, an individual's social time preference has been contrasted with society's, and for public investment decisions it has been suggested the market-determined evaluation of future consumption may be rejected in favour of a politically determined rate: '...the political process may be involved because the market cannot express the "collective" demand for investment to benefit the future and because we may prefer the weights of some political process to those of the market place' (Feldstein, 1964). These attitudes characterise the implications behind the persistance of forestry claims for national capital, while usually making an indifferent showing of the probable profitability of such an investment. The statement also exemplifies how far development economics has come from the price-dominated market, and has authoritarian overtones which have been recognised as being in the category of 'dictatorial preference functions' (Eckstein, 1958). Modification of incentives by use of lower interest rates by government agencies can often lead to difficulties in maintaining efficiency and

> '...analysis of government expenditure needs to be more careful than that for private firms as the overall objective is so complex. Internal government staff should engage in mutual criticism to a greater extent, they have special allegiances and may develop goals of their own and confuse allegiances' (McKean, 1958).

Probably the exposition of the case to consider values, and the recognition of the reluctance with which long term investment is made, has been the most useful contribution of development economics to forestry. The introduction of the idea of the social time preference rate as against the opportunity cost of capital (Feldstein, 1964; Henderson 1965) has not resulted in any further detachment of the choice of an interest rate, beyond indicating society as a whole may have different time preferences to an individual. The use of social time preference rates in production forestry rests on whether the products are public goods. Production forestry is not essential in the same way as are public utilities, and the mixture of public and private enterprise in forestry makes any leniency in applying interest rates only dubiously valid; forest products are freely subject to substitution and sell only on their relative value for their price (1), and the case for using 'social time preference rates' hardly arises. The claim that forest products are indispensable has been termed 'clearly absurd' (Leslie, 1967): it is akin to a stronger claim by agriculture that, as food is vital, agricultural production is above economics. When the latter view is

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(1) Ignoring external influences, such as tariffs, on the price mechanism.

promoted by agriculturalists to justify competitive land acquisition, the need for economic analysis is often stressed by foresters. The further idea that forest products are public goods <u>because</u> of the long investment period required for their production (Beazley, 1965) is equally illogical.

It has been accepted that theory alone cannot provide an absolute rule for the choice of interest rates: 'The search for a perfect formula to specify the social time preference rate is futile...it must reflect public policy and social ethics; as well as judgement about future economic conditions...it must be administratively determined as a matter of public policy' (Feldstein, 1964).

For United States corporations: 'in practice top management determines the guiding rate of return and theoretically it should not be more than the firm's long term cost of capital' (Fedkiw, 1960), although the difficulty remains that even this cost may be unknown. While it is accepted elsewhere that the decision on what interest rate to use can only be taken centrally by the government, the difficulty remains that there is no unique or agreed way of arriving at such a rate (Henderson, 1965). '...the choice of an appropriate rate of interest ... in other fields of long term development ... does not appear to have reached a much more definitive stage than in forestry' (Leslie, 1967). Fundamentally, a central decision has to be taken on the rate of interest which could vary with economic conditions and which lacks an objective basis.

Since an objective way of determining interest rates is not available, it is necessary to review rates which have been used in practice. Antagonistic views on the use of market rates include: their use as a last resort (Henderson, 1965); that they are 'irrelevant for public investments because there is no market on which a closed economy as a whole may borrow or lend' (Dorfman, reported in Treloar and Morison, 1961); and that they have no objective basis (McKean, 1958). Contrary opinions include their use in agricultural case studies, recognising they exist in the form of mortgage or bank overdraft rates (Ward, 1964a) or more strongly: 'that no method which attempts to avoid the difficulty of specifying an appropriate market interest rate for long term planning can be successful' (Chisholm, 1963).

There is no more an absolute, or pure basis, of setting an interest rate (or rates) to ration capital, than there is for deciding which proportion of income should go to labour for wages, or to rent - the availability and cost of capital will depend on the circumstances of the organisation and country at any particular time and the approach used here is empirical. Consequently the rates which have been used, or are now current, are of particular relevance, as are the circumstances under which these rates apply.

A tabulation of various rates is given in Table 6-1, and their contexts are given below. Agricultural development is an appropriate basis for comparison with forest development, since the time scales are over at least one decade and so approach those of forestry; and both industries require land on a large scale. Rates studied for North Island development were $4\frac{1}{2}$ to $6\frac{1}{2}$ per cent, while the predominant rate used was $5\frac{1}{2}$ per cent (Chisholm, op. cit.). This compares reasonably with the average annual rates of return on farm capital of from 3.7 to 5.5 per cent for sheep farms in 1958/9 - which was a poor year for farm prices (Keen, 1961) and of 5.5 per cent return on capital for Southland (N.Z.) fat lamb farms in 1959/60 (Warner, 1961). (1) The latter farms are amongst the best in the country. Nevertheless lower rates are available, charges of from three per cent being made by the Marginal Lands Board and mortgage rates of from three to five per cent from the State Advances Corporation. These rates compare with the 5½ per cent set in the study of land development schemes for agriculture in Queensland in 1963; this rate was considered to be equal to the present long term, risk-free interest rate (Bur. Ag. Econ., 1963). Rates of four to six per cent were used in another New Zealand agricultural and forestry study as they were assumed to be realistic for present and future conditions (Ward et al , 1966). Where choice of an interest rate was rejected, a range of from nought to ten per cent was tested in a Western Australian analysis (Treloar and Morison, 1963). Use of the United States 'President's Water Resources Council's' method would lead to use of a rate of around 5.4 per cent in New Zealand in 1967/68 (Jensen, 1968).

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(1) The World Bank report quotes rates of return of dairy and sheep farms in 1963/64 of from 9.1 to 13.0 per cent (Anon, 1968b). It is not possible, from the data given, to decide if interest on farm development capital is included or not (if it is omitted, the rates given are then parallel to the 'forest rent' concept).

Comparable agricultural and forestry comparisons in the United Kingdom used rates of three to seven per cent (Walker, 1960) and also of three, five and seven per cent for inflation-free estimates (Anon, 1966a). Calculations of the United Kingdom Forestry Commission generally used a rate of $3\frac{1}{2}$ per cent on the grounds this is near the rate earned, and also the rate at which money was advanced to the Commission (Grayson, 1962; Sinden, 1964). Neither reason is persuasive in the context of current European economic development, but is justified on the grounds of the relative security of the investment and of the imponderable advantages to be derived from forestry. The calculated rate has now been found to be $4\frac{3}{4}$ per cent in the United Kingdom (Anon, 1966a). Hiley (1956) used a rate of four per cent for evaluating forestry in the United Kingdom, while estimating that returns from equities ranged from $3\frac{1}{2}$ to 12 per cent, with a mean value of five per cent for growth stocks (then).

> 'Returns on industrial investments are not as high as sometimes thought. The net of tax return on equities in real terms (including growth in capital value) has been in the range of five to six per cent over the last four decades, while Consols have yielded, again in real terms, negative returns.' (Anon, 1966a).

The utility of forests in providing fringe or imponderable benefits from Federal ownership was thought to reduce interest rates in the Pacific North West of the U.S.A. to below three per cent, while rates of six and 12 per cent were employed for other ownerships (Anon, 1963a). A study of the economics of second-growth sugar pine management in California used a risk-free rate of $2\frac{1}{2}$ per cent, which was the yield on long term Government bonds at that time (Vaux, 1954). Earlier, a rate of between $2\frac{1}{2}$ and $3\frac{1}{2}$ per cent had been suggested for use in the U.S.A. (Thomson, 1942), and three per cent has been used more recently in studies of white pine in New England (Dowdle, 1962).(1) A range of from three to five per cent was used to evaluate Douglas fir second growth in British Columbia (Haley, 1964). The actual results of the American sawn timber industry showed an average return of about five per cent on capital from 1929 to 1959 (Zaremba, 1963).

It has been argued that the role of forestry in large, wood-using corporations in the United States represents a risk reducing investment, since supply of raw material to the utilization plants is safeguarded, and a hedge provided against future rises in price of raw material (Fedkiw, 1960).

(1) White pine syn. strobus pine.

In these circumstances, a rate of as low as three per cent was suggested in evaluating purchase of timber producing lands. Further investment for stand improvement, such as access for thinning, or pruning, should then be assessed at a higher rate, as it was argued that while the fixed assets necessary to safeguard long-term timber supply are largely an unavoidable cost, further management aimed at improving assets needs a higher rate to direct management effort into the best opportunities; the industrial plants are assessed at a third - and highest rate. In Sweden, where the reforestation of forest lands is compulsory wherever returns of (as low as) $2\frac{1}{2}$ per cent are possible, Streyffert (1960) reported 'This may be the only forest law existing that has the return on investment as the guiding principle for judging the investment in reforestation to be required from the forest owner'. The rate of $2\frac{1}{2}$ per cent in this was not chosen from theoretical arguments but:

> 'it was simply found that one had to lower the rate...to this level... to arrive at the amount necessary to carry out reforestation... Despite this low rate of return, the Swedish Government borrowing at rates of around five per cent, investment in reforestation proceeds beyond the requirements of the law by all forest-owning groups.' (Streyffert, op. cit.)

The large utilization companies wish to safeguard their supplies, as in North America, and the idea that profit maximising is a fundamental goal of all aspects of management is thus in effect denied. The net result of these interpretations of the role of forests is to favour the development of vertically-integrated industries which obtain much of their initial capital cheaply in the form of unexploited, existing forest. The subsequent capital investment in utilization plants is both more expensive than forest development and, in the case of pulp and paper plants, immobile. These considerations cannot be applied to economies in which the pre-existing raw material base is absent - that is, which establish utilization industries based on plantations. These would have to bear comparison with the opportunities available in the investment of the capital in other projects. The forest and the utilization plant could be considered together, at least where they are within one country.

Outside forestry and agriculture, somewhat higher rates appear to be used; that suggested as the social cost for water resource utilization in the United States was from five to six per cent if an efficient allocation of resources equal to the opportunity cost is taken

(Krutilla and Eckstein, 1958); but this was considered likely 'to preclude the justification of most projects' (Eckstein, 1961). The opportunity rates of five to six per cent were admitted to be at least of that order (Eckstein, op. cit.) but were queried (Hirshleifer, 1961). Hirshleifer's estimate of the Federal riskless rate was around four per cent or $3\frac{1}{2}$ per cent after allowing for the built-in inflation represented in the four per cent. When risks were incorporated into private utilities, he considered rates of nine to ten per cent were appropriate. The minimum internal rate of return required on investments in the Continental Oil Company was ten per cent (McLean, 1958). The rate used in public investment in France is seven per cent (Boiteux, 1964) although there is no indication that the national forests are managed on such a basis. This is also the rate which has been used to evaluate the Channel tunnel scheme in the United Kingdom (Henderson, 1965). A distinction should be made between the loan rate and the expected profit rate, the former is being considered here. A final choice is that range of rates which appears reasonable in the circumstances of forestry in New Zealand. In national terms a country with relatively poor capital availability may assess time preference differently to one richly endowed. Lacking capital, in the form of credit or overseas reserves, a country may prefer to use the resources in the form of time - that is as deferred returns - rather than find a large sum at the end of this period. On a practical level it is feasible for a national forest policy to adopt extensive pruning aimed at an eventual supply of high-grade sawn timber, rather than leaving the forests untended and later converting the wood to say, chemical pulp, with a heavy final requirement of capital. The smaller but more regular inputs of capital necessary for the pruning/sawlog alternative may make this the more attractive alternative if capital is relatively scarce. Alternatively, in a rich country, greater value may be attached to getting returns on capital rapidly. In effect the form of capital availability may lead to different national time preferences because of the nature of the inputs. The physical input from extensive pruning is mainly in the form of labour at the time of the operation, but this is usually dwarfed by the compounded interest charges at maturity.

New Zealand is relatively poor in natural resources and the policy of providing employment in secondary industries protected by import control has interfered with the price mechanism: 'it has enabled industry to pay for resources at a higher rate of return than is justified on the basis of goods produced in comparison with extra imports afforded by extra exports' (Philpott, 1961). Logically either a lower rate of interest should apply to evaluating export-potential industries or equivalent import-cost prices should be used to assess profits in the secondary industries. The latter alternative is preferable as it is set by world prices, and also avoids further debate on the choice of an interest rate.

Empirically the rate of return on capital in New Zealand agriculture is an appropriate rate at which to evaluate an export-oriented forest industry, as agriculture represents a comparable export-oriented industry, which also requires land, as well as labour and capital, as a major input. Both the idea of social opportunity cost and social time preference can be considered; in New Zealand - a young, developing country - the demand for investment capital is high. But at the same time personal standards of living, based on current consumption, are also high and the demands that these standards be raised, for example to the level of those of the United States, have formidable political influence. The argument that forestry is not necessarily essential and is subject to changing technology has already been mentioned. In these circumstances, rates of interest of $2\frac{1}{2}$ to $3\frac{1}{2}$ per cent are believed to be unreasonably low, and a government decision to adopt such rates at the expense of consumer demand might result in a large forest investment, which may become obsolete because of technological developments. The classical necessity of rationing capital remains, despite the extreme attitude that 'capital rationing is unlikely to arise in a strict sense and...in practice it is usually the result of miscalculation' (Hirshleifer, 1958). Practically, of course, all governments face capital rationing.

The low rates of $3\frac{1}{2}$ per cent and under are rejected here despite the use of three per cent in the New Zealand farm forestry schemes loans; (even though the rate was reduced from five per cent to three per cent following lack of farm afforestation at the higher rate). In this case, the rate reflects the level at which individual farmers are prepared to borrow, rather than the expected rate of return from the investment (which has not been demonstrated). In the context of Government investment in New Zealand, with the range of alternative investment opportunities available, together with the imperatives of broadening the economy and increasing export income, a three per cent rate of interest is considered too inefficient a screen for long term capital investment, and a minimum rate of four per cent is proposed. Even this is well below the interest rate paid on government loans, although it is higher than the rate ($3\frac{1}{2}$ per cent currently) paid at call to depositors in Savings Banks. The overseas loans raised by the New Zealand Government in 1966 and 1967 were at $6\frac{1}{2}$ to $7\frac{1}{2}$ per cent.

At the other end of the scale, rates above eight per cent would exclude much medium-term (about thirty years) investment, and are considered to be unduly high for the amount of speculation involved in forestry; after all forest products supply a wide range of established markets, production and distribution services. Private firms are currently paying around $7\frac{1}{4}$ per cent for overdrafts, and unsecured note issues are at from six to nine per cent, large companies floating debentures at around the seven to eight per cent mark; internal Government loans are at from $4\frac{3}{4}$ to around $5\frac{1}{2}$ per cent. Most of the capital required initially for expanded afforestation will come from the government, and from internal national capital; imports represented only five per cent of forestry's (not forest industries) costs in 1959/60 (N.Z. Dept. of Statistics, 1966); the amount of private capital likely to be invested is debatable. As eight per cent is considered to be too high, and three per cent too low, a range of rates from four to seven per cent inclusive will be predominantly used in this study. It is reiterated that the rates chosen are arbitrary, and have not been based on any objective method of assessment; economic theory in any case cannot provide for such an assessment. The rates of four to seven per cent bear comparison with the availability of internal government capital at the present day; if a single rate had to be chosen, one of six per cent would be selected deliberately to screen out longer term specialised projects which the rate of technological change is most likely to invalidate.

(b) SOCIAL COSTS

Housing and roads (1) comprise social costs in forestry. The extent to which these costs should be allocated to production depends on circumstances. In Britain, it was argued that inclusion of forestry's housing costs depended on whether they represented net claims on national resources, because if the workers

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(1) The provision or upgrading of roads which are otherwise unmade, or below standard, is a social benefit, providing public access is allowed. Examples are in the construction of gazetted but unbuilt public roads in Rankleburn, Golden Downs, Hanmer and Waipoua forests, among others.

were not housed on forests, they would be housed elswhere 'by town corporations and we should...only charge the extra cost (if any) of providing forestry houses' (Walker, 1960). Walker concluded '...on economic grounds the inclusion of such costs is not correct'. Forests established to utilize existing labour resources, as in Northland and Westland in New Zealand, have a local cost advantage in using existing rural housing, when compared with forest extension in areas lacking housing. Perhaps nationally only the differential cost of rural housing should be charged but the real differential cost may depend on housing standards. National policy may require higher standards than exemplified by current Northland rural Maori houses. Social cost should be considered independently in each analysis and, to allow for ready comparisons, its effect should be expressed separately.

(c) METHOD OF EVALUATION ADOPTED

Although theoretically sound, C-B ratios are not employed in this analysis (with a minor exception). They are excluded partly as the definition of 'benefit' presents practical difficulties, for example: an intermediate yield incurs a certain cost K, and a gross return R; if both K and R are discounted to the year of origin of the project, the final cost-benefit ratio will differ from that of discounting the net R-K (whatever the sign of this expression). This is only a procedural difficulty and a uniform definition could be made within a given series of studies. In wider comparison difficulties could arise; in the United Kingdom, for example, thinnings are usually sold on stump, whereas in New Zealand sales are often 'on ride'; adjustments may be necessary which are not required by other criteria. In addition cost-benefit ratios are currently little used in New Zealand forestry, and overseas appear to be less used than the I.R.R. and L.E.V. Cost-benefit ratios have no outstanding advantage over the longer established methods which would compensate for the objections (of procedure, and of easily comparable results) outlined.

The objection to the I.R.R. in having potentially multiple solutions has been found empirically to be of little moment in evaluating New Zealand afforestation results, due to the simplicity of a case in which there is only one (major) change in signs in a net cost or revenue stream; that is where net costs are incurred up to a certain year when they are replaced by annual flow of net returns. The practical objection to the I.R.R. is its relative insensitivity. It is still useful, however, to know the I.R.R. generated by a given forest project as it allows a further comparison with other industries. The P.N.W. and its derivative traditional forestry form of L.E.V. can give anomalous results when negative values are calculated - a project can become less unprofitable as the interest rate rises. Allowing for their limitations, the criteria of I.R.R. and L.E.V. are used here, as internal and international forestry comparisons are facilitated (and land values are, to some extent, evaluated in the process).

Use of the Faustmann formula, with a constant annual charge for all indirect expenses, is likely to give optimistic results when afforestation is expanded. This is due to the heavy indirect capital costs usually incurred before any additional forest areas are planted which can carry the extra capital expense. Consequently an approach based on annual budgeting has been used here, in preference to the simple formula.

There appears to be no overwhelming case for the use of either a unique criterion, or of a given interest rate; there are theoretical or practical objections to all the criteria. In this case any of the criteria can give useful results if the analyst is aware of their limitations. Perhaps it is necessary to reiterate the objection to the over-facile use of the Faustmann formula -

devised to test profitability at normality - for the very different circumstances of expanded afforestation, and also the unexpected anomaly in the L.E.V. criterion in given circumstances at negative values. The approach adopted is empirical, based partly on what is theoretically sound, partly on the circumstances of the local economy, and partly to allow of comparisons inside forestry.

The case of plantation forestry analysed here is in terms of its commercial profitability. New Zealand is a young, developing country where the allocation of resources of land, capital and labour should, at the very least, be known in terms of relative profitability, whatever the final basis adopted for the decision on any project.

TABLE 6 - 1 INTEREST RATES USED

Rate per cent	Context	Source
	UNITED KINGDOM	
$3\frac{1}{2}$-$4\frac{1}{2}$	Government stock	Hiley, 1956
4	Forestry	" "
$3\frac{1}{2}$	State forestry	Hummel and Grayson, 1962
$3\frac{1}{2}$	" "	Sinden, 1964
3-7	" " and agriculture	Walker, 1960
3-7	" " " "	Anon, 1966a
$4\frac{3}{4}$	" "	" "
5	Public investment criteria	Henderson, 1965
7	Channel tunnel	" "
	FRANCE	
7	Public investment criteria	Boiteux, 1964
	SWEDEN	
$3\frac{1}{2}$-$4\frac{1}{2}$	Government stock	Petrini, 1953
4	Forestry	" "
	UNITED STATES OF AMERICA	
$2\frac{1}{2}$-3	Public forestry	Duerr, 1960
3-5	Corporation forestry	" "
$2\frac{1}{2}$	Forestry	Vaux, 1954
$2\frac{1}{2}$	U.S. Government debt	Davis, 1954
3-4	20-year terms in valuation problems	" "
3-4	Long term loans	Guttenberg, 1950
4-6	Short term "	" "
5	Public investment criteria	Eckstein, 1961
10	Oil company investment decisions	McLean, 1958
	AUSTRALIA	
5	Forestry and agriculture	Lewis, 1967
$5\frac{1}{2}$	Agriculture	Bur. Ag. Econ., 1965
	NEW ZEALAND	
$4\frac{1}{2}$-$6\frac{1}{2}$	Forestry and agriculture	Chisholm, 1963
4-6	" " "	Ward et al., 1966
5	Agriculture - mortgage rates	Ward, 1964
$4\frac{1}{2}$	Forestry	Anon, 1913
7	"	(1), 1968

(1) Treasury directive to author, 1968.

CHAPTER 7 - THE IMPONDERABLE AND SECONDARY - ECONOMIC EFFECTS OF PLANTATION FORESTRY IN NEW ZEALAND

This work is primarily concerned with the direct profitability of plantations, but as emphasis has been placed in development economics, (McKean, 1958), and in forest policy on both imponderable benefits and on secondary-economic effects, some consideration of these - even if only their enumeration - has to be made. The benefits of indirect effects has been particularly stressed in forestry, being characterised by the resolution of the committee on Forest Policy of the 1962 British Commonwealth Forestry Conference that:

> '...any consideration of the economics of forest management must take into account the commodity value of the manufactured products and all the indirect benefits of the forests..[these].include conservation of water supplies, development of rural industries, and communities, increased taxes of many kinds, savings of foreign currency and recreational values,...it is highly desirable that values for these factors should be included...(or at least these)...benefits should...always be referred to' (Anon, 1962a).

These indirect benefits can only be assessed on a relative basis; most other rural industries can contribute similar extraneous processing increases; and forestry, in common with other rural industries incurs indirect costs as well as benefits. The external diseconomies '...have not normally been referred to in analyses of forestry proposals' (Leslie, 1967). Full analysis of all these factors is excluded, since the subjects are extensive, and many - particularly multiplier effects and autarchy - would justify comprehensive study. A more detailed analysis of labour's situation in forestry is made, as labour forms a high proportion of the direct costs (1) and is a scarce "commodity", but the other aspects are only briefly discussed.

(a) CLIMATIC EFFECTS AND THE WATER REGIME

The net results of the physical effects of forests can only be assessed for particular geographical areas, and the benefits then depend on the values-at-risk or on the neighbouring land development pattern. This complexity makes generalizations such as "conservation of water supplies" (Anon, 1962a) inappropriate.

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(1) Salaries and wages comprised 42 and 50 per cent of the costs of forestry and sawmilling respectively in 1959/60, (N.Z. Dept. Statistics, 1966); and Table 7-8.

These roles for all New Zealand State exotic and most large private forests of over 1,000 acres are summarised in Appendix 9. Two overall effects can be safely ascribed to exotic afforestation: the wind velocities on neighbouring areas are reduced, though the extent of these benefits are not known; and a high degree of soil stability is attained under exotic forest. The soil stabilization effects to date are of particular value only on limited areas, where forests were established partly or largely for erosion control; though the derived downstream effects may be included as benefits in much of New Zealand. In discussion of erosion on Taupo pumice the view that land development for agriculture 'has undoubtedly aggravated the tendency to erosion, but it seems likely that erosion would have occurred in any case' (Healy, 1967) was modified, after correspondence; erosion on similar soils under exotic plantation being acknowledged to be negligible. (Fenton/Healy, pers. comm; November, 1967).
In this case forestry has a considerable protective benefit.

Detailed consideration of the net effect on overall water supply by afforestation is excluded from this study; in some areas reduction in total water flow may be beneficial, in others it may represent an economic loss. For example, the finding that afforestation with radiata pine resulted in reduced water availability (due to canopy interception) in a city catchment plantation (Fahey, 1964) characterises a case where a net cost is incurred; such interception in other cases may be beneficial; by contrast, interception could, if necessary, be reduced by different afforestation techniques - such as wider spacing.

The relatively small number (five) of pulp and paper mills has restricted public criticism of the effect of atmospheric and water pollution. The Tarawera river, rising in pumice land and effectively filtered of any sediment in an up-stream lake, is typically clear, and above Kawerau is still an excellent trout-river; after receiving effluent from the Tasman and Caxton mills at Kawerau it is undrinkable, and no longer supports life. The down-stream farming community have all received direct compensation for loss of a pure water supply, and alternative facilities have been provided for each of several hundred farms; but the loss to the community is the replacement of a clear life-supporting river by one which is opaque and poisonous. In complete contrast, the effect of afforestation alone (ignoring pulp mills) on the rivers and lakes of the North Island pumice land is beneficial, as forestry's relatively great advantage over agriculture is in non-enrichment of water with dissolved nutrients. Forestry preserves the characteristic '...pellucid waters...and is pre-eminent in retarding normal trends towards eutrophication' (1) (Anon, 1967b).

Changes in soil fertility can usually be assessed economically by changes in increment rates. In the instances where plantations are converted to agricultural uses, the extra costs of stumping and clearing can be calculated directly.

(b) CONSERVATION, WEEDS AND PESTS

State exotic forests are sanctuaries for indigenous, and some exotic animals. The main groups benefited are native (e.g. ducks) and introduced (e.g. pheasants) game birds. Other exotic mammals are classed as 'noxious' and are killed where possible, although it is possible that the original intentions (in part) of acclimatization societies in introducing such animals as opossum and deer in providing further income from meat and/or skins may be realized in future. Although now generally fire-free, exotic forests provide a rather limited number of niches for animals or plants.

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(1) Eutrophic - an ecological term signifying a lake environment characterised by shallow sloping shores, and a belt of dense aquatic vegetation.

(It is common observation that native robins, for example are now much more easily seen in exotic, rather than indigenous forest).(1) Specific provision for sanctuaries in exotic plantations have been made as at Esk for kiwis, and for an endemic plant of restricted distribution - Pittosporum turneri, (Petrie) - at Erua.(1)

Provision of fire-fighting facilities is a benefit to rural communities.

Production forests may also be centres for the spread of noxious animals and weeds; in New Zealand the Noxious Weeds Act is not binding on the Crown, and so, under poor management, forests can harbour ragwort, gorse, and other weeds. Similarly goat, rabbit and wild pig populations can increase but these potential pests can be eliminated by good management. The costs depend on particular circumstances.

(c) HUMAN EFFECTS WITHIN FORESTRY: DIRECT EFFECTS

Plantation forestry remains an arduous and often monotonous job, despite increasing mechanisation. Some measures of its acceptability by labour can be demonstrated by the record of strikes, and labour turnover; the demand or otherwise, for employment; and the acceptance of new working methods.

Robins - Miro spp.; kiwis - Apteryx spp.

The loss of working time from strikes has been confined almost entirely to the pulp and paper section of the industry. Sawmilling - for an industrial activity - has had an exceptionally strike-free history since at least 1945. Strikes of plantation workers are rare, the only record of any strike for over thirty years was in late 1967, when a dispute arose at Kaingaroa forest. The exception to forestry's overall good record for industrial stability is the pulp and paper industry; established on any scale only from 1954. This industry has a high rate of strikes, both in relation to other forestry activities and to all industries, and details are given in Table 7-1. Further, the only large-scale strike of logging workers occurred in the Kaingaroa Logging Company - a wholly owned subsidiary of one of the two large pulp and paper companies. Strikes in these industries have more harmful derivative economic effects than in forest operations, as the capital employed per worker is higher.

One reason why strikes are so rare in New Zealand plantation forestry may be the exceptionally high rate of labour turnover - labour being too mobile to stay long enough to establish causes of trouble. The general level of overall unemployment in New Zealand has been extraordinarily low - registered unemployed have exceeded one thousand only twice in twenty years to 1965, when totals of 1188 and 1040 were recorded in 1959 and 1962 (N.Z. Dept. Stats., 1959 and 1962), and the ease of finding work undoubtedly allows a high degree of labour mobility. The lowest rates of labour turnover in the Forest Service were in 1958 and 1959, which were years of relative financial stringency. A more marked change came in 1967, when unemployment rose through the year to total 6-7,000. Forestry then resumed its historic role as a utilizer of otherwise unused resources - in the case of unemployed labour forestry's capacity to utilize otherwise unemployed labour is responsible for the low historical cost of much of the plantation resource; keeping men in work at times of unemployment is a benefit, but usually yields direct financial gains.

The percentage of labour turnover depends on the definition used, the convention here is:

$$\text{Per cent turnover} = \frac{\text{Number of employees leaving} \times 100}{\text{Total number employed at a given date}}.$$

Turnover data in the N.Z. Forest Service are given in Table 7-2. The figures include: sawmill workers - who represent about a quarter of the total labour employed; protection, and indigenous forest employees.

The turnover rate of 45 per cent (basis not given) of the Tasman Pulp and Paper Company was termed '...bad for any business' (Schmitt, 1967), and its effects '...in an isolated community with many specialist skills...are relatively more severe'. (Schmitt, op. cit.) than in a large society. It follows that the even higher rate in Forest Service operations is more serious, and probably shows forestry work has been poorly accepted by labour. The uneven demand on the labour force - requiring the fittest and relatively hardest-working of the country's population is normally an extra social cost; its effect varies with the particular age/sex distribution in the population at a given time. The virtual absence of unemployment up to 1967 and the lack of appeal of forestry as a job lead to a very fluid labour position. This results in inefficiencies in operations which are reflected in the direct costs. It has been estimated that the total cost to an employer when a worker leaves is $140, (N.Z. Dept. Labour, 1966), this figure being 'typical of costs of labour turnover throughout New Zealand industry as a whole' (N.Z. Dept. Labour, op. cit.). It is possible that, due to the unskilled nature of much of the work, the cost of retraining and hence of 'worker termination' in forestry is somewhat lower than this $140 average.

The accident rate for forestry and related industries is high (Tables 7-3a to 7-3c). Unfortunately the figures given include the indigenous industry; work in the latter is in generally steeper, higher-rainfall areas; with larger and less uniform logs; and in poorly equipped sawmills. It is probable that the better organised, more uniform plantation based work is less risky. The Economic Severity Rate Index in Tables 7-3a/c is weighted by the age of the injured men and shows forestry's demand is primarily for young men. It would be reasonable to associate part of the high accident rate with the high labour turnover rate; the subject warrants further research. Absolute comparisons cannot be made over time and between industries until the definition and reporting of accidents are uniform; an accident is now defined as any injury which results in loss of paid working time. The statistics are probably influenced by the growing awareness of accident costs and the growing tendency for all accidents to be reported; in exceptional cases accidents may <u>not</u> be reported in order to preserve a 'clean' safety record. The compensation paid in the N.Z. Forest Service has not shown much tendency to rise, despite the greater proportion of workers in the more hazardous utilization jobs compared with the late 1940's (Table 7-4).

The relative direct losses through accidents in all industries are ten times higher than through strikes, when compensation payments are compared with pay lost, and accidents have longer term social disadvantages. The high accident rate in forestry and its associated activities outweighs the relatively low rate of strikes, and is an imponderable cost.

The change over from straight wages to 'incentive and bonus schemes took some time to become operative' in the N. Z. Forest Service, and were adapted 'after some reluctance' (Hinds, 1962) and eased the labour shortage. Trade Union attitudes to safety precautions are generally positive, acceptance of incentive schemes is widespread in, for example, N.Z. Forest Products Ltd.

Acceptance of safety precautions is improving, for example safety helmets are now almost always worn and safety boots are increasingly used; more specialised protection such as ear-muffs for docking-saw or planer operators, seems to have a lag period before being generally accepted. The absence of any tradition of industrial bitterness probably helps the acceptance of new methods in forestry.

(d) HUMAN EFFECTS - WITHIN FORESTRY; SOCIAL EFFECTS

Forestry - particularly State forestry - entails social disadvantages to its workers and supervisors; these arise as it is a largely monolithic rural industry in which the ultimate employers are a few Government Departments or large companies. Forest workers are generally poorer than the relatively affluent farmers who are their neighbours, the latter being exceptional, by world standards, in exceeding the levels of most other self-employed people (Slattery, 1966). For forestry workers the ordinary rural disadvantages of poorer educational, religious, cultural, medical and commercial services, together with, for example, high food, power, and service charges are not compensated either by the satisfaction of working for oneself (as do farmers) or until recently by high wages, as obtained by agricultural contractors. A desirable change to direct contract work - in the national agricultural tradition - is now under way. If this is extended forestry will be able to compete more equably with agriculture in offering incentives for high work outputs. Thus by paying a given sum for a given operation - for example, a price for thinnings deliveredat forest ride - savings in overhead can result, and direct payments can increase. However, it is essential to maintain quality standards.

The normal disadvantages of rural life are compounded in forestry by the difficulty of living together in isolated villages, where a supervisor lives next door to an employee. Such a housing organisation has the disadvantages of a traditional agricultural tied-cottage system with the additional difficulty of having the Officer-in-charge living adjacently. An observer from outside forestry indicated '...the senior local representative of the private company or government department...is the only person who can authorise even minor repairs to residential or communal facilities. He therefore tends to be the sole arbiter of the way in which the settlement is run' (Chapman,1966). Chapman continued '...an articulate minority of Kaingaroa...is irritated by the dual role of employer and village administrator that the...Forest Service is required to perform'. Regarding buildings 'Except for the bungalows occupied by married couples, with which most tenants are fairly well satisfied, Kaingaroa's buildings have the appearance of a temporary bush camp rather than the permanent centre of a large, perpetual, and highly profitable forest operation'

(Middleton and Jane, 1964). Much lower standard married accommodation than at Kaingaroa is, of course, still occupied at, for example, Karioi, Conical Hill and Waipa and many private company forest and mill villages. The contrast to the owner-occupier status of most farmers is considerable. There are two reasons why the situation is not worse: there is a shortage of cheap houses to rent in New Zealand, and these are available in many forest villages; and the majority of the occupants are used to the conditions, and the peculiar social structure of supervisor and worker living adjacently is accommodated with common sense. Nevertheless this is a social cost, and concern is apparent. An investigation into Kaingaroa village (the largest N.Z. Forest Service settlement) has been made by a University Psychology Department (N.Z. For. Serv., 1963) (1). The increasing recognition of the problem is exemplified by a policy of transferring the isolated forest villages into existing settlements or, at least, to forest margins and main roads. (N.Z. For. Serv., 1965).

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(1) Kaingaroa...'Although (or perhaps because) it is by no means a normal community, is...probably the best described social unit in the country' (Middleton and Jane, 1964). These authors, architects, referred to the single men's huts as "dog boxes".

Previous attitudes considered:

> 'The greater part of forest labour in New Zealand consists of left-overs from the general labour pool...most forests are in relatively isolated localities which have no social amenities such as public houses and cinemas...Greatly raised standards of accommodation and catering over many years have failed to improve matters' (Entrican, 1957).

Forest management has indeed improved standards over those previously existing in forestry, but as these still remain below those elsewhere, labour is still difficult to obtain.

A similar situation exists for the utilization companies. The Tasman Pulp and Paper Company's recruitment of labour was facilitated by housing, 'for all New Zealand recruited workers provision of housing or accommodation was a drawcard...' (Schmitt,1967). The company however recognised aspirations and '...home ownership schemes...were...put into operation to satisfy the natural and proper desire of people to own their own homes, to enhance the stability of the labour force and to enable the company to withdraw at least to some extent from the undesirable status of landlord, as well as employer...' (Schmitt, op.cit.).

In forest villages, these disadvantages can often be set against hunting and shooting facilities for forest labour, and, for some staff, the opportunity to eventually run a forest. Overall it is the wives and children of the forest workers who have to bear the greater part of the social disadvantages of forestry, and the indirect costs it entails.

One particularly undesirable consequence of the pulp and paper industry has been the virtual establishment of three company towns, where the inhabitants overwhelmingly depend on one industry. These are Murupara (logging), Kawerau and Tokoroa (pulp and paper). Another plant is better situated near an established town - Whakatane. In addition to the social disasters if the men were sacked, the effects of strikes disproportionately affect derivative local prosperity. The full potential of the labour force may not be utilized, once an initial recruitment stage is over. In the smaller forest villages'...which have been established for at least 15 years, the limited number of job vacancies often influences the parents of teenage children to move to larger centres ' (Chapman, 1966).

In the Company towns this may be deliberately circumvented by mill policy, for example: there are few jobs for women, but they are employed in paper packing and checking work which could otherwise be mechanised. Other disadvantages of one company and one industry towns are susceptibility to any depression in the industry; possibilities of victimisation after strikes, and the disproportionate effect of personalities (viz. between a union leader and company manager), and a change in jobs probably requiring a change of house.

Finally in large-scale organisations, management is often remote; the disadvantages incurred in state forestry were previously summarised as '...over centralisation and suppression of initiative in the junior members of the service...' (Hiley, 1930).

(e) HUMAN EFFECTS - EXTERNAL TO FOREST EMPLOYEES

External social effects of forestry are generally beneficial and usually include: aesthetic and recreational benefits; and more debatably the decentralization of the population.

The amenity value of forests is relative, depending on the population density, its distribution, income and tastes; and on the alternative facilities available.

The current and growing emphasis on forests as a source of recreation in the eastern U.S.A. (Gould, 1962) and in Europe reflect their high populations, growing affluence and relatively limited forest resources. As with other forestry concepts, the overseas developments may not be applicable to current conditions in New Zealand. Extensive tracts of indigenous forest are close to most of the populated areas, and the preference of the public is probably for indigenous forest. For example: natural regeneration of exotic pines is cut down in National Parks (Anon, 1963b); the Ministry of Works removed self-sown and largely mature radiata pine, during beautification of the Aratiatia Hydro-electric scheme, and replanted with indigenous shrubs; the public are indifferent to organised tours of Kaingaroa Forest (Grayburn et al, 1965). The management attitude to recreation in both private and State Forests has until very recently been antagonistic and the 'Keep Out' signs persisted until 1966 despite statements in 1953 that they would be removed (N.Z. For. Serv., 1953). The particular example of Whaka Forest - one of the oldest, most varied and pleasantly planted exotic areas - adjacent to the tourist town of Rotorua has been an unfortunate example (Fenton, 1965b) but has not excited public animosity as abundant alternatives have been available. The results have been 'at no stage has the Forest Service publicised the recreational possibilities of the forest, nor has any attempt been made to improve or provide recreational facilities...In the past the policy has been to close all exotic forests to the public, and legislation provides that trespassers may be fined. To date the attitude has been to exclude the public.' (Grayburn et al, 1965). Apart from limited shooting and fishing facilities, which in any case are often 'an important feature in retaining a stable labour force on a forest' (Grayburn op. cit.), few recreational benefits can be claimed from the past. Recently (1967) the management attitude has changed and positive efforts are made to admit the public. Again Whaka forest provides a convenient example where the planting of diverse species on major road boundaries, and the admission of the public to some roads and viewpoints now exemplify acceptance that 'recreation is a respectable use of the forest' (Gould, 1962).

Due partly to the high cost of providing good communications and service facilities in great cities, and partly to the desirability of establishing rural industries (Anon, 1962a) maintenance of a relatively large rural population is a political aim in many countries. (Stewart, 1958; For. Comm. Vic., 1962).

It is debatable if equal servicing is achieved, and the point that cities in the countryside, rather than forest villages are required, was stressed. 'there has been much lip service to decentralization, but it has little prospect of lasting success unless what the large cities have to offer in work opportunity, retail trade, sport, entertainment, cultural activities and higher education can effectively be decentralized in quantity'. (Lewis, 1966). Further 'the Government Departments, are each forced to operate within the stringent budget of a government department, (and) frequently have sufficient funds for little more than village maintenance, to the obvious detriment of the community they are called upon to administer' (Chapman, 1966). The relative unattractiveness of rural life to those unaccustomed to it is shown by the loss of overseas immigrants from forestry (N.Z. For. Serv., 1949).

A greater effect of rural population via rural forestry is the enormous level of transport cost in forestry. When comparisons are made between quite good grade (e.g. five ewe equivalents per acre class country) agriculture and average forestry yields (Ward et. al ,1966), forestry has at least 50 times the mass to shift per acre than agriculture. The overall primary and secondary roading (not the ultimate open roads) equal the intensity required in agriculture, but the standards required are higher due to the overall weight moved and the road quality needed for high speeds. Naturally, forestry greatly increases traffic in rural areas, and where public roads are inadequate may incur indirect costs. The recent Japanese log trade has involved the export of 230,000 to 390,000 tons of logs annually up to 1966 with heavy traffic and road wear locally. The traffic in 1965-66 was largely concentrated in the Bay of Plenty area, and amounted to at least 130,000 truck ton-miles per day for 300 days per year. A further million acres of exotic forest would result in the annual production of about 6,000,000 tons of final crop saw-logs alone (Fenton, 1965b) - equal to half the total tonnage now shifted by New Zealand Railways. This excludes any intermediate crops or final products. The very presence of forestry greatly improves road standards - if not density - but at a cost which has to be set against the benefits of decentralization. Afforestation to provide future traffic for non-paying local railway lines can occur, and was used in argument against the closure of the

Nelson-Glenhope line in the South Island. The net benefit, if any, depends on the circumstances.

When a primary reason for afforestation is to utilize available rural labour as on the West Coast of the South Island, then forestry should presumably get some credit. Often these schemes are political, and much of the emphasis for rural population is transparently so.

Although no figures are available, forest industries probably employ a disproportionately high proportion of Maoris. The degree of social integration is high, and little trouble arises. At Kaingaroa a psychologist noted that although '...few Maori workers aspire to join the permanent staff of the Forest Service on a lower, fixed salary (than their high contract rates)...race relations...approximate much more closely to the New Zealand ideal than they do in other New Zealand communities of which we have any detailed knowledge' (Groves, 1962). Ritchie, however (reported in Chapman, 1966) found the two groups (European and Maori) 'live alongside one another rather than together' in an anonymous Central North Island forest village (identified by the writer as Kiorenui (1) - a Forest

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(1) From details given of its size, plan and buildings.

Service village adjacent to Murupara; the contrast in race relations between Kiorenui and nearby Kaingaroa is difficult to account for).

(f) DERIVATIVE ECONOMIC EFFECTS - PROCESSING BENEFITS

Various indices have been used for measuring the importance of plantation forestry, these include the gross return, or export income earned, per unit of capital and per acre (Thomson and Grainger, 1961), and per man employed (Larsen, 1960). A more comprehensive analysis which also compared agriculture and forestry has been made in the U.S.A. but based on a largely exploitive forest industry. (Ruttan and Callahan, 1962). The argument that value per unit of physical input (logs) must be maximized, that a nation 'must strive for the highest form of processing possible' (Larsen, 1960), depends on the relative rate of returns on the capital employed (Grayson, 1962). From New Zealand export figures (Fenton,1968b) it is apparent that, because kraft pulp mills cost at least ten times as much as sawmills per unit of input, chemical pulp gives a lower return in relation to the capital employed than timber, or even the log trade. If social costs were charged for the pollution effects of pulp mills, the difference would be further increased. Similar projections of the profitability of timber, plywood, kraft-pulp and newsprint in British Columbia showed the anticipated rate of return from the extra processing capital of the more intensive industries was little different from that of sawmilling. (Rankin, 1963). In New Zealand's case the 'first-crop' logs used for kraft pulp would produce far less readily saleable timber if diverted to a sawmill, and the production of kraft pulp for export is incidental to the economics of large-scale pulp production needed for domestic paper making. Consequently the maximization of value output per unit of physical input depends both on the degree of capital and alternative investment availability, and also on the potential for the end-use envisaged for the raw material.

The direct increase in values by the further processing of standing trees, whether merely by logging or by subsequent manufacturing is of major importance in assessing forest profitability. Indications of the order of increases in value resulting from processing are given in Tables 7-5 to 7-7. The degree of indirectness of forest products in an economy has been summarised as 'a high degree of indirectness and of interdependence with other factors' (Westoby, 1962) but the size of these effects depends on the country concerned. The relative contributions of forestry and agriculture are given (for 1959-60, at present the only year for which uniformly based statistics are available) in Table 7-7. The data in Tables 7-5 to 7-7 generally support Westoby's statement, forestry evidently does have considerable multiplier effects.

In plantation forestry, the division between the growing of trees and the primary utilization by sawmilling, or by pulp and paper manufacture is increasingly indistinct. The concept of an organization growing and selling trees is now frequently irrelevant to the development of forest produce corporations, though historically the function of State forest departments. The role of the independent tree growing company is diminishing rapidly as such companies now own only three per cent of the total exotic forest area and 'it is doubtful if this type of company will have any significant effect on the future forestry picture in New Zealand' (Groome, 1964). Utilization companies have largely bought up the existing afforestation companies, while the Tasman Pulp and Paper Company and other utilization firms are establishing forests of their own. The North-Western American ideas of a free log market, where competitive bids are made by various buyers or of similar European auctions of timber lots, are unlikely to develop for plantation regimes where the trees are grown for a given purpose and often sold on a long term basis.

In this study assessment of forest profitability has been taken through to the end of primary manufacture in some cases, and so accommodates the direct processing costs and profits of forestry and allows for the capital cost and profits of utilization plants.

Forestry's contribution to the economy beyond the stage of primary manufacture is more diffuse, and would require detailed and critically assessed data to evaluate, warranting further research beyond the assessment of direct profitability. The danger of double counting these effects is considerable. (Leslie, 1967). The relative inputs of forestry and agriculture are given in Table 7-8 for the years 1959-60; the proportion due to wages and salaries is much higher than in farming and the major farm-derived industries.

Multiplier effects through the provision of specialised equipment depend in part on the overall scale of the forest, and of other industry, and the sophistication and extent of industrial production. Perhaps due to the absence of competing demands which a more varied economy would make, there has been considerable development of logging and sawmilling machinery in New Zealand; the Kaingaroa Logging Company, for example, build up their own trucks, chassis and trailers (Nellbeck, 1965); bandmills are manufactured, and developments in high pruning (Reid, 1963) and wood preservation equipment are quite advanced. The stimulus of forestry in a relatively unindustrialised country may be more important than in a wider based economy.

The subject extends into autarchy, and overseas trade. Theoretically, a nation which does not necessarily manufacture equipment itself may be able to buy the best available from overseas. The relative availability of overseas exchange, and whether it is 'hard' or 'soft' can then affect decisions. The level of customs duty on imports may greatly increase internal costs - rates of from 50-100 per cent apply to such items as straddle and endlift trucks in New Zealand.

(g) DERIVATIVE ECONOMIC EFFECTS - DEFENCE; AUTARCHY

New Zealand plantations have had no direct defence benefits comparable, for example, with the forests of the Ardennes, Vosges, and Jura in Western Europe in obstructing invading armies. Their strategic benefit is in the form of replacements for imports in times of

war or economic stress. As such they have the same contribution as any other substitute that can be developed (for example, by working lower grade, local ores) if overseas supplies are limited. The level of benefit depends on the likelihood of the scarcity of other imported resources - for example, oil is probably currently a greater benefit to South Africa than wood - and on the degree of substitution that can be employed. Forest development for strategic purposes provides classic examples of the obsolescence induced by changing technology in the provision of ship oak in the early nineteenth century, and of pit-props in the 1920's in the United Kingdom, neither product being generally required as such when it was eventually available.
In New Zealand, afforestation with eucalypts was initially made to provide local sources of durable species; (apart from the lack of success of these plantations), they were unnecessary in view of the present development of the preservation industry. Past exotic afforestation in New Zealand was primarily to ensure continuity of wood supplies - (this is discussed in Chapter 12); current policy is to provide for an export surplus.
A forest policy of autarchy is a continuation of the fundamental tradition of maximizing physical yields,

and autarchy is as contrary to the doctrine of comparative advantage as forest rent is to economic efficiency. The place of autarchy in an economy is contentious (Kindleberger, 1958) and beyond the scope of this study, but the New Zealand economy is dominated by a narrow range of natural resources, and consequently is dependent on trade if living standards are to be maintained. Forest products trade regained an international surplus in 1963 (Fenton, 1968b); and while experience in meat and dairy export products show the classical arguments of comparative advantage are of dubious application in world trade for a small country with a limited range of exports '...forestry's prospects are as dependent as agriculture's on the vagaries of other countries' import policies, but forestry does provide one of the few export alternatives for New Zealand's limited resources.' (Fenton, op. cit.). The value of imports and exports in forestry and forest industries is given in Table 7-9 for 1959-60, export values are given in greater detail elsewhere (Fenton, op. cit.).

The effects of using export as well as domestic prices are investigated in the ensuing budget calculations in Chapters 8 and 9.

TABLE 7 - 1 RECENT STRIKES IN FOREST INDUSTRIES

	Forest Industries			All Industries	Per cent Of work force in		Of Total time lost in Strikes
Year	Industry	No. of Strikes	No. of man-days lost	No. of man-days lost 000	All forest Industries	Pulp & Paper	
1965	Pulp & Paper	2	596	21.8	5.4	1.0	2.7
1964	-			66.8			0
1963	Logging	1	1962	54.5	5.3	1.0	3.6
	Wallboard	1	22				
1962	-			93.2			0
1961	-			38.2			0
1960	Pulp & Paper	3	6363	35.7	5.6	0.9	17.8
1959	" "	3	845	29.7	5.4	0.8	2.8
1958	" "	2	1150	18.8	5.4	0.8	6.1
1957	" "	2	550	28.2	5.4	0.8	1.9
1956	" "	3	2514	23.9	5.6	0.8	12.4
Ten Year Totals ,000 man-days							
All Forest industries			14.4	410.7			3.5
Pulp & Paper only			12.0				2.9

The pulp and paper industry only began at any scale in 1954; 1954 and 1955 were strike free in forest industries.

Sources: N.Z. Dept. Statistics 1955-66; Yska, 1967.

TABLE 7 - 2 LABOUR AND STAFF TURN-OVER

N.Z. FOREST SERVICE (1)

Year	Labour		Staff	
	Total (2)	Per cent turnover	Total (2)	Per cent turnover
1965	2290	195	1989	15
1964	2158	183	1894	14
1963	2151	171	1781	14
1962	2038	153	1750	16
1961	1866	140	1643	15
1960	1817	140	1608	16
1959	1654	115	1552	15
1958	1689	121	1451	19
1957	1683	177	1399	17
1956	1832	154	1211	21
1955	1952	154	1151	15
1954	1900	144	1071	15
1953	1974	169	1023	17
1952	2069	131	928	14
1951	1875	145	826	13
1950	2026	136	790	12
1949	1881	142	757	10

(1) All figures derived from appropriate Annual Reports, N.Z. Forest Service.

(2) Total at the end of the year.

TABLE 7 - 3a ACCIDENT FREQUENCY AND SEVERITY IN INDUSTRY, 1963

Industry	Accident frequency rate (1)	Injury severity rate (2)	Economic severity rate (3)	Deaths
Forestry	8.94	1,543	1,932)	7
Logging	16.89	13,865	15,431)	
Sawmilling	7.75	2,037	1,999	0
Paper and paper products	5.15	1,047	1,255	0
Coal mining	29.62	6,226	5,348	1
Loading and unloading vessels	11.13	3,709	3,556	- (4)
All manufacturing industries	4.89	1,075	1,096	4
All industries	3.65	1,134	1,172	74

(1) Number per 100,000 hours worked.

(2) Hours lost per 100,000 hours worked.

(3) Hours lost per 100,000 hours worked, weighted by the age of workers in the case of permanent disability or death.

(4) Not given separately.

Source, Anon, 1965a.

TABLE 7 - 3b ACCIDENT FREQUENCY AND SEVERITY IN INDUSTRY, 1964

Industry	Accident frequency rate (1)	Injury severity rate (2)	Economic severity rate (3)	Deaths
Forestry	7.78	1,518	1,095	1) 5
Logging	16.95	10,806	11,195	4)
Sawmilling	7.66	2,929	2,771	1
Paper and paper products	6.01	2,907	3,439	1
Coal mining	30.51	9,072	8,789	4
Loading and unloading vessels	9.41	4,886	3,782	3
All manufacturing industries	5.14	1,214	1,207	4
All industries	3.75	1,145	1,147	67

(1) Number per 100,000 hours worked.

(2) Hours lost per 100,000 hours worked.

(3) Hours lost per 100,000 hours worked, weighted by the age of workers in the case of permanent disability or death.

Source, Anon, 1966c.

TABLE 7 - 3c ACCIDENT FREQUENCY AND SEVERITY IN INDUSTRY, 1965

Industry	Accident frequency rate (1)	Injury severity rate (2)	Economic severity rate (3)	Deaths
Forestry	7.09	698	878	0)
Logging	15.90	17,235	16,384	7)[7]
Sawmilling	6.80	2,658	2,213	4
Paper and paper products	5.69	1,723	1,945	1
Coal mining	28.61	4,921	3,913	0
Loading and unloading vessels	9.77	2,752	2,452	0
All manufacturing industries	4.76	1,261	1,216	15
All industries	3.46	1,150	1,197	90

(1) Number per 100,000 hours worked.

(2) Hours lost per 100,000 hours worked.

(3) Hours lost per 100,000 hours worked, weighted by the age of workers in the case of permanent disability or death.

Source, Anon, 1967c.

TABLE 7 - 4 ACCIDENT TOTALS, FREQUENCY AND COST;
N.Z. FOREST SERVICE

Year	Total number of accidents	Total of accidents per 100 employees (1)	Compensation paid (2)
1965	860	31.8	1.62
1964	907	NA	1.40
1963	827	NA	1.52
1962	684	27.6	1.83
1961	637	28.0	1.65
1960	621	28.0	2.03
1959	549	26.9	2.08
1958	510	24.8	1.56
1957	527	25.9	1.78
1956	591	27.7	1.35
1955	557	24.9	1.36
1954	497	22.9	1.32
1953	462	16.7	1.11
1952	520	22.6	0.79
1951	366	17.6	1.37
1950	510	22.9	1.86
1949	552	26.6	1.62
1948	421	NA	0.99
1947	382	NA	1.75

(1) A quarter of the total staff employed are included in these figures, as well as total labour.

(2) Compensation: \$ per \$100 of wages.

Sources - Annual reports, N.Z. Forest Service, and direct data.

TABLE 7 - 5 INCREASED VALUE OF WOOD AFTER PROCESSING

Country		Export logs	Sawn timber	Plywood	Pulp & Paper Chemical pulp	Pulp & Paper Newsprint
Values(1)						
New Zealand 1964 exports		26	32	-	45	89
World	(2)	-	27	39.5	56(2)	
British Columbia	(3)	-	31	-	53	84
Relative capital ratios						
British Columbia	(3)	-	1	0.6	5.7	8.6

Figures are based on conversion factors of 6 bd.ft/cu.ft for saw timber; 113 cu.ft/ton for newsprint; 178 cu.ft/ton for chemical pulp.

(1) Values in cents per cu.ft round produce equivalent.

(2) Westoby, 1962; the type of pulp was not specified.

(3) Rankin, 1963.

TABLE 7 - 6 NEW ZEALAND - INCREASED VALUES OF WOOD AFTER PROCESSING - 1964-65 (1)

	Saw milling	Planing, joinery	Plywood & veneer	Pulp & Paper	All forest industries(3)	All N.Z. industry	Per cent forest + forest industries(4)
A - value of output(2)	50.5	59.9	6.8	55.2	228.4	2175.4	10.5
B - value added in manuf-acture(2)	27.6	24.2	3.5	38.0	115.0	841.2	13.7
C - value of plant and premises(2)	17.8	15.2	3.0	52.0	108.1	747.3	14.5
Ratio of A/C	2.8	3.9	2.3	1.1	2.1	2.9	

(1) Source, Yska 1967.

(2) Million dollars.

(3) Includes categories not specified here.

(4) Forestry and forest industries as a per cent of all industry.

TABLE 7 - 7 VALUE OF OUTPUTS IN FORESTRY, FOREST INDUSTRIES AND AGRICULTURE, 1959-60

Outputs in $ million

Item		Output	Item		Output
1	Forestry	30.0	6	Farming	819.1
2	Sawmilling	45.1	7	Meat (1)	281.7
3	Planing mills	18.4	8	Butter and cheese	182.0
4	Joinery	19.6	9	Other milk products	44.3
5	Pulp and paper	41.9	10	Wool scouring	2.0
			11	Wool milling	14.7

Ratios

Of items $1:\Sigma 2\text{-}5 = 1:4.2$

" " $1:\Sigma 1\text{-}5 = 1:5.2$

" " $1:\Sigma 1\text{-}5$ plus wooden containers, plywood and veneer, other wood products, furniture, cartons and paper bags, and paper products.

$= 1 : 7.24$

Of items $6:\Sigma 7\text{-}11 = 1:0.64$

" " $6:\Sigma 6\text{-}11 = 1:1.64$

" " $6:\Sigma 6\text{-}11$ plus ham, bacon, animal feed, tanning, fell-mongery, leather goods, animal and vegetable oils, grain milling

$= 1 : 1.70$

(1) Meat freezing and processing

From Table 1-1, Part 1, N.Z. Dept. Statistics, 1966.

Table 7 - 8 INPUT COEFFICIENTS IN FORESTRY, FOREST INDUSTRIES, AND AGRICULTURE 1959-60

	Salaries and wages	Other value added	Imports	Indirect tax	Subsidies	Depreciation
Forestry	.426	.420	.050	.013	- .003	.094
Sawmilling	.506	.315	.063	.016	- .002	.100
Planing mills	.497	.289	.111	.016	- .001	.084
Joinery	.545	.265	.101	.018	- .001	.068
Pulp and paper	.390	.298	.142	.023	- .002	.143
Farming	.224	.563	.092	.045	- .005	.077
Meat (1)	.328	.471	.091	.037	- .004	.074
Butter, cheese	.257	.566	.097	.045	- .045	.076

(1) Meat freezing and preserving.

From Table 2-2, Part 2, N.Z. Dept. of Statistics, 1966.

TABLE 7 - 9 IMPORT AND EXPORT VALUES - FORESTRY, FOREST INDUSTRIES AND AGRICULTURE, 1959-60

$ million

	Imports	Exports
Forestry	1.0	1.1 (1)
Sawmilling	1.2	2.4
Planing mills	1.2	-
Joinery	1.0	-
Pulp and paper	3.9	11.2
Farming	31.5	192.6

(1) Only logs and poles are counted as 'forestry' exports. Fuller details of exports are given in Fenton, 1968b.

From Table 1-1, Part 1, N.Z. Dept. of Statistics, 1966.

CHAPTER 8 - THE PROFITABILITY OF DOUGLAS FIR

(a) THE AREA CHOSEN AS A MODEL

A detailed analysis of exotic-forest profitability based on radiata pine has been published for the Maraetai district (Ward et al, 1966; Fenton and Grainger, 1965). This block of 25,000 acres is representative of much of the Bay of Plenty/Taupo region where present and prospective forest-land of similar quality and topography comprises over 400,000 acres (Table 8-1). These areas have favourable characteristics for forestry, notably:

(i) an initial vegetational cover which is relatively easy to suppress;

(ii) extensive areas of topography and soil suitable for tractor operations, with few surface streams;

(iii) climate and soil favourable for tree growth and, below 2,000 ft, having high site-quality;

(iv) the most extensive utilization industries in New Zealand.

These factors make the Bay of Plenty/Taupo region particularly favourable for afforestation and economic results from here can provide the first components of a national cost-of-supply schedule (Hummel and Grayson, 1962). The results already available for the Maraetai blocks are extended in this Chapter to cover Douglas fir afforestation; the original radiata pine results are modified in Chapter 9, and analysis of both species is extended to include utilization industries.

Because of the planned rapid increase in national afforestation, an equally rapid build-up of the forest model based on the Maraetai blocks has been allowed and the subsequent conversion to normality is complex. The analysis has been by budgeting, based on detailed costing of annual programmes. The result is a voluminous series of schedules of physical, management, and economic calculations, which have been presented separately (Fenton, 1967c), but are summarised below and in the Appendices.

(b) MANAGEMENT PROPOSALS

Currently it is unprofitable to extract thinnings from steep slopes, therefore topography determines management divisions. Costs for large-scale tractor extraction of Douglas fir thinnings, for example, are around 7c. per cu.ft but hauler thinnings on steep topography costs 16-20c. per cu.ft (Fenton, 1967a). Consequently the block is divided into two areas: the Thinning Working Circle (T.W.C.) of 18,600 acres net (1)

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(1) The difference between the net 20,800 acres and the gross 25,000 acres of the block is ascribed to the areas occupied by roads, buildings, fire-breaks and other unplantable land.

and which can be extraction thinned; and a Hill Working Circle (H.W.C.) of the remaining 2,200 acres net which is managed without thinning. Frost flats of 1,600 acres net in the T.W.C. are to be initially planted in lodgepole pine and converted to Douglas fir under a shelterwood system.

To maintain comparability between the species, management parallels that of radiata pine. An intensive land-clearing schedule is followed by rapid afforestation, completed in 19 years. All planting is at 8 x 6 ft spacing and three release-cuttings are prescribed (four on the H.W.C.). Formal management prescriptions are over-rigid, as in practice latitude could be allowed in conversions of frost-flats, and in thinning intensities after age 35, with a more even spread of work and yields. Every variation of thinning would, however, require recalculation of tree - and log-diameter distribution and no full yield-tables are available to calculate these.

Projections have included three alternative regimes - A, B, and C - to convert the T.W.C. to normality, and the differences between them are summarised in Table 8-2. The alternatives were chosen to find the financial differences between sacrificing increment by felling early or by maintaining higher volume yields in later years, with delayed returns. In A, half of the first cycle of the T.W.C. is treated by the prescriptions given (viz.- thinned to the given intensities at 35 and 42) while the remaining half is clear-felled at age 30. Regime B is similar, but clear-felling of unthinned stands is postponed until age 35, and then applies over a larger area. (Volume increment is high between ages 30 and 35). In regime C no unthinned stands are clearfelled; clear-felling begins at age 42 in stands which have been thinned at age 35, and stands are thinned again if necessary at 50 and 60 years of age until eventually clear-felled at ages 70-76.

The H.W.C. is converted to normality on a common basis for all regimes, the first rotation is planted over five years and felled over 20 years from ages 30 to 45. The next series of felling coupes are reduced to the normal acreage and begin at age 30 and end at age 45; operations are thereafter normal on a 35 year rotation.

Details of area, volume and labour requirements are given for regime B in Appendix 10, full details for all three regimes are given elsewhere. (Fenton, 1967c)

(c) COSTS - FOREST

Costs of operations are taken from the radiata pine study (Ward et al, 1966; Fenton and Grainger, 1965) with modifications necessary for the change in species. The charging of costs through time varies with the regime; the annual allocation of each cost heading is exemplified for regime B in Appendix 11. Unit forest costs vary little with the species, but utilization costs require adjustment.

Logging costs have been tied to two fixed points: the clearfelling costs for unthinned stands, which can be adopted from figures for radiata pine and from small areas of Douglas fir; and the direct clear-felling costs of 3.0c. per cu.ft, and man-hour-production (M.H.P.) of 110 cu.ft, used in the radiata pine study. The latter stand would comprise 80 s.p.a.; free of malforms; pruned to 36 ft and previously extraction thinned. The cost - directly advised and confirmed by the Forest Service logging section for use in the original Maraetai analysis - is probably too high. The capital equipment, logging hauls and tree-sizes were specified and the given crew of six men with tractor, arch and loader would have to fell, haul and load only six trees per hour to maintain such a rate. Work study results suggest this rate could be tripled without difficulty. By retaining this cost the cost-reduction gradient from unthinned stands is probably unduly gentle and does not reflect the full benefits of the tending operations for either species.

Summarised logging costs are given in Table 8-3 for unthinned, and Table 8-4 for thinned stands. Details of M.H.P; labour force; logging-equipment cost and supervisory staff are available for each regime. (Fenton, 1967c).

The lower green weight of 47 pounds per cu.ft for Douglas fir, compared with 58 for radiata pine (Hinds and Reid, 1957) reduces haulage costs, and a 20 per cent reduction has been allowed. The rates available are for contract haulers and include a profit margin. Haulage costs are often the deciding factor in profitability, because they are the easiest costs to isolate. They give a differential effect <u>depending</u> on the regime. Mill location on the forest instead of at Tokoroa, would increase the profitability of regime A more than that of regime C, as the lower conversion factors (1) for small logs results in

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(1) Conversion factor. Viz.- the factor expressing the sawn yield in bd.ft from the log volume in cu.ft. For example - a yield of 60 bd.ft from a 10 cu.ft log would result in a conversion factor of six.

proportionately less sawn timber to be carted, details are in Appendix 12. To maintain equal social benefits between two species, the mill is still assumed to be located at Tokoroa for the Douglas fir analysis, and haulage costs are given in Table 8-5.

(d) COSTS - MILLING

The highest cost in a forest managed for saw-logs is that of sawing itself. It is necessary to define the type of mill; its capacity; running cost; and profit. The type of mill required depends on the log-diameter distribution, the latter is summarised for Douglas fir in Table 8-6. Logs of six to eight inches small-end-diameter (s.e.d.) have been frame-sawn to cants in New Zealand since 1940. The use of machines with shorter sash depths and increased feed-rates have raised throughputs, but their use for such small logs has been accepted uncritically, though analysis has shown (Williams, 1956; Fenton and Brown, 1963) that losses are incurred on logs of up to 7 in. s.e.d.

In both Australia and South Africa twin - or parallel-circular saws have been preferred. In Sweden logs of under eight in. s.e.d. were usually sawn by circular-saw mills and the extension of frame saws to cut cants (as against live sawing) from logs of seven inches s.e.d. has been 'recent' (Reiersen, 1959).

The use of twin-circular and band-saws for small logs is increasing in Sweden (Endersby, 1966). Figures for throughput of a twin-circular headsaw in tandem with a deal-frame in South Africa (Deetleefs, 1964) showed a lower throughput than the maximum obtained with tandem frame-saws in New Zealand. Despite its low capital cost and its use overseas, the twin-circular type of mill is almost unrepresented in New Zealand and frame-mills have been used in this analysis. Although this only follows what happens in practice it may unfairly increase cost of production of Douglas fir (although subsequent figures show a low cost of sawing).

Tandem frame-saws give high throughputs for logs of nine to 14 in. s.e.d. but it is an open question whether the figures could not be bettered by a band-saw headed mill of suitable design. Data from both State mills, as designed in New Zealand, show substantial cost advantages for frame-mills over band-mills for logs up to 14 in., when production is of optimum sized cants for re-sawing; after 14 in. the band-mills become cheaper (Williams, 1956).

The type of mill specified partly defines its capacity; for the Douglas fir regimes sufficient logs of 15 in. and over are available to occupy a moderate-sized band-mill of a one-shift capacity of 50,000 bd.ft.

Four tandem frame-saws would then be required at normality to cut the smaller logs on a one-shift, five-day-week basis. Details of mill capacity and sawing costs are in Appendix 13 and conversion factors in Appendix 14 while summarised results are in Table 8-7. The net result is a lower sawing cost than for radiata pine, despite smaller log diameter. The reasons for this result are:

(i) The Waipa band-mill cost, used in the radiata pine study of $1.90 per 100 bd.ft is high for an average log diameter of over 15 in. It contrasts with an average cost of $2.16 per 100 bd.ft, for the entire cut of Conical Hill State mill in 1962, which was for a mean log size of only 11.2 in. s.e.d. and an overall cost of about $1.90 reported as the average cost of sawing of all radiata pine in 1957 (Hinds and Reid, 1957). To some extent this high cost is accounted for by the high conversion-factor and grade yield allowed in the radiata pine study.

(ii) The analysis given, and Conical Hill Mill's average results, show frame-mills are efficient in producing timber at low cost from logs in the 9 to 14 in. s.e.d. range.

(iii) An overall reduction of costs of ten per cent was allowed for increased scale of production. Further, neither dipping to prevent sapstain nor grading are required for Douglas fir.

(iv) The analysis made is a first step to optimizing forest/mill design. The total capacity of the band-mill has been adjusted so that both mill types cut for most of the time in the log sizes which they convert most efficiently.

Undoubtedly, sawing costs need to be more accurately known. On the trend of the figures shown here, there is a relatively small decrease in sawing cost with increase in log size above 14 in. s.e.d. and plantation forestry inevitably produces high volumes of six to 14 in. s.e.d. logs. The cost of mills is high and their use for only a 40 hour week is expensive as labour costs comprise only 40 per cent of the cost of sawing in these highly capitalized mills (compared with 50 per cent in all N.Z. mills).

(e) REALIZATIONS

Saw logs are the only source of revenue. Realizations for Douglas fir depend largely on the sizes produced. There are only limited markets for one-inch boards and the quantity sawn depends on the proportion of small log-diameter-classes, supplemented by boards unavoidably produced from resawing of waney framing from larger logs. The main demand is for framing in house-construction and the main size required is 4 x 2 in., then other framing sizes up to 6 x 2 in. A demand certainly exists for larger framing, notably as industrial purlins, and there is a positive price-size gradient, but in 40 years time large volumes of timber will be available which can fill this demand. These will be from: the increased afforestation of Douglas fir itself; from other species, particularly on steep sites where intensive tending is not practicable; and from the remaining areas of the 800,000 acres of untended 'first-crop' exotics. Consequently the present margin for 8 x 2 in. and larger sizes has been allowed, but with relatively limited production. Some larger sizes could be obtained from clearfellings of even 30 year old stands, as 11-13 in. s.e.d. logs are produced. The overall result is a decline in one-inch board production with increasing age, but only a modest gradient of increased production of larger framing sizes. Details are given in Table 8-8.

This contrasts with size and grade distribution allowed for radiata pine, where management would favour the production of wide clears. Good quality framing timber can be grown satisfactorily with a minimum of attention, intensive tending being unnecessary. The high site quality that enables pruned radiata pine rotations to be reduced to 26 years is as high as can be accepted for Douglas fir where some timber will already be grown at faster than five rings to the inch.

Three basic price levels have been used:

P-1: the actual domestic wholesale price list as at April, 1962 (the date used for the radiata pine price list).

P-2: As for P-1, but reducing the price of framing timber by $1.50 per 100 bd.ft - the cost of preservative treatment. The need for treatment is debatable. Possibly grading for a given proportion of heartwood or for strength may be introduced. The overall price level is close to the average export price at wharf of $6.00 to $6.60 per 100 bd.ft.

P-3: As for P-2, but reducing the price of one-inch boards to the equivalent of Merchantable (N.Z. Standards Inst., 1962) radiata pine. The grade is interchangeable for such uses as diagonal bracing and baffle boards; the greater strength of Douglas fir makes it superior for some end-uses (as in bracing) and conversely the dressing qualities of pine are superior in other uses (as in cupboard fittings).

Realizations based on three price levels have been used for the three regimes and are given in Table 8-9. A fourth price - to test the effect of exporting the same per cent ($37\frac{1}{2}$) of produce as for radiata pine in PR I - has been calculated for regime B. Details are in Appendix 15, and summarised effects on realizations are in Table 8-10.

The sawmill location at the town and railhead of Tokoroa, and the extra haulage charge this imposes suggests the sale of mill slabs as pulpwood chips. The market for these would be the kraft pulp-mill at Kinleith. Details are calculated in Appendix 16. (The effects of including credits for pulpwood chips on the L.E.V. of regime B at P-1 are given in Table 8-13).

A third set of realizations has been prepared by including the sawmill costs and profits in the forest budget. (The logging cost and capital has already been included.) The effect of mill profits varies with the regime, since they come into effect earlier with A, than with B, or C. The original difficulty of having to estimate mill capital cost remains; to maintain comparability with radiata pine a similar proportion of capital to profit less a reduction due to scale of production has been taken. This assumption is only a compromise to enable some estimate to be made of the effect of incorporating the mill into the forest budget. The data are imperfect due to lack of detailed mill capital costs for the scale and type of mill envisaged. The effect of including mill capital and profit, with and without social cost, has been calculated for regimes A and B, details are in Appendix 16. (The effects on L.E.V. are shown in Table 8-11).

(f) METHODS OF CALCULATION

Costs are common for regimes A, B and C in the establishment and maintenance phase up to year 29. After this year, costs are taken net of income for the three price levels P-1, P-2, and P-3 for each regime; social costs have been calculated separately. The annual money flows have been compounded at four to six per cent interest to the year 100 when the forest is normal for all regimes. The forest cost is then reduced to an L.E.V. by:

(i) allowing a final half year's interest, to allow for charges and returns falling throughout the year, rather than at the end of it;

(ii) adding $100,000 a year in the annual cost for working capital;

(iii) finding the annual cost or returns net of (i) and (ii);

(iv) reducing (iii) to a per-acre basis, capitalizing and then discounting to the year one.

The results showed some positive values at six per cent interest, and results were calculated at seven per cent for price levels P-1 and P-2. Social costs showed negligible differences (when rounded to the nearest dollar) between the regimes at five and six per cent interest, and the cost calculated for regime B at seven per cent has been assumed to apply to the other two regimes. Results for L.E.V. are given in Table 8-11.

Results are best for regime B and then A at the higher interest rates. The effects of including the mill cost and profit in the overall analysis has been calculated for regimes A and B at four to seven per cent interest with and without social cost. The relative results are the same for all price levels. Details are in Appendix 16 and the effect on L.E.V. in Table 8-12.

Finally the effects of export prices on L.E.V. for regime B for four to seven per cent interest for the three domestic price levels P-1, P-2, and P-3 have been found. To facilitate comparisons, the effect of all alternatives are summarised for regime B in Table 8-13.

The I.R.R. were found graphically. Results for domestic prices including and excluding social costs are shown in Figures 1 and 2. Figures 3 and 4 show the effects of including the mill with the forest budget for regimes A and B, again both including and excluding social costs. In Figures 5 and 6, the effects are shown of including the mill costs and profits with a proportion of export sales in regime B, both with and without social costs. Results of the I.R.R. are given in Table 8-14.

(g) RESULTS. I - INCLUDING SOCIAL COST

(i) DIFFERENCES BETWEEN REGIMES

Results of L.E.V. are in the following order for the three price levels:

per cent interest	4	5	6	7
P1 and P2	C>B>A	C=B>A	B>C>A	B>A>C
P3	"	B=C>A	"	

results given by I.R.R. are:

P1	B>C=A,	total	range	0.2	per	cent
P2	B>C>A,	"	"	0.25	"	"
P3	B=C>A,	"	"	0.3	"	"

There is little to chose between I.R.R. of the three regimes, and the financial loss in choosing C or A at an interest rate of five per cent is small.

This lack of outstanding financial superiority is a desirable result, since within the limits of the analysis, it gives flexibility to management. The practical application may then depend on how urgently the timber is required - within 30 years if A is followed, or whether physically greater yields (1) are desired later - as in B. The shorter rotation involving loss of increment results in only a modest fall in profit even if interest rates are less than five per cent, the profit difference decreases further at higher interest rates.

Expressed from the other point of view, the physical increment of Douglas fir, and its interaction with unit costs per log-size and timber size out-turn, is sufficiently high to counteract increasing forest capital costs, within the limits of the analysis.

(ii) EFFECT OF INCLUDING THE MILL IN THE FOREST BUDGET

The effect of including the mill is to increase the I.R.R. of regime A by 0.35 per cent, and of B by 0.25 per cent at P1 to 6.9 and 7.0 per cent respectively. The effect is greater at lower price levels, I.R.R. being raised 0.8 and 0.5 per cent respectively at P3, but L.E.V. are still negative at six per cent interest.

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(1) Totalling 120 million bd.ft over a 22 year period.

The inclusion of mill results with the forest must inevitably increase profitability, as the mill cost of production includes a net profit rate of 15 per cent on capital cost. (1) The figures give some indication of the order of this increase for a wholly saw-timber forest; whether it is important depends on the circumstances.

The per cent increases in L.E.V. for regime A and B at P1 levels are:

per cent interest rate	4	5	6	7
regime A - per cent increase	23	32	66	80
" B " " "	21	27	50	100

Although this overstresses its importance, the effect of including sawmill capital and profit will be to increase L.E.V. up to the point where the mill profit rate is achieved. The proportionate increases at P2 and P3 are much greater, since net forest profitability is lower.

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(1) This allowance is that made by N.Z. Forest Service timber sales procedure, it has no particular economic validity. However, the rate is allowed to mills in calculating net forest realizations; hence when forest and mill are considered together, this component can be credited to both.

(iii) INCLUDING EXPORT PRICES

The results of allowing for exports are similar to those of incorporating sawmill profits, but opposite in trend, and the overall effect at P1 level is more severe. For regime B the two effects on L.E.V. (in $ per acre) are:

per cent interest rate	4	5	6	7	
including mill	+40	+22	+12	+6	(at all price levels)
exporting, P1 prices	-70	-40	-24	-16	
" P3 "	-20	-12	- 7		

The P3 level is reduced least by inclusion of average export prices as it is the closest to the average export realization (at mill). The effect of their inclusion is discussed further in Chapter 11 as are the effects of different price levels.

(h) RESULTS. II - EXCLUDING SOCIAL COSTS

The exclusion of social cost increases the number of L.E.V. which break-even or are positive; all regimes approximately break-even at seven per cent at P1, but none reach six per cent at lower prices. If the mill is included and social costs are excluded, regime B makes six per cent (actually 6.3) at P2; regime B also makes six per cent if exports are included in the forest budget, but mill results are excluded at P2 levels. These effects are also discussed further in Chapter 11.

Overall, the results for Douglas fir show constant trends, reflecting the stabilising (or dampening) effects of the lengthy non-productive period and then the ability of the species to maintain a value increment which is close to the final I.R.R. The conclusions, under the assumptions and limits of the study are:

(i) Douglas fir is highly profitable at a four per cent interest rate.

(ii) It can return $6\frac{1}{2}$ per cent, if social costs are included, for the regimes tested, if sales are made at domestic prices.

(iii) If forests are largely for export (with prices at P3 or less) the rate of return is less than $4\frac{3}{4}$ per cent.

(iv) Inclusion of sawmill profit and capital, while increasing L.E.V. (at four to six per cent) substantially, raises the I.R.R. by 0.2 to 0.6 per cent.

(v) The range of rates earned under the most extreme of the assumptions is from 4.75 to 7.4 per cent.

(vi) Considerable managerial flexibility is maintained at little financial sacrifice.

(I) RESULTS. III - FORMAL DIFFERENCES BETWEEN CRITERIA

The results by I.R.R. give the same ranking as by L.E.V. at six per cent interest, (as the I.R.R. is close to six per cent). At rates below this, the advantage of regime B decreases and is supplanted by regime C at four per cent, when the postponed, but heavier yields, become more profitable. If the graphs are extrapolated to eight per cent, regime A becomes the best (although all L.E.V. are negative) and the order of preference is reversed. This is an orthodox demonstration of the differential effect of the criteria, although in this case as the I.R.R. is close to the chosen rate of six per cent there is little practical difference between the results. The I.R.R. can be an insensitive indicator in forestry, particularly in this case where the first yields are not until year 30 or 35.

The use of L.E.V. here has assumed that the initial land cost is nil, the actual cost (if any) of land would have to be subtracted from the L.E.V. if land was not free. In this case L.E.V. per acre equals the net difference between discounted revenues and costs (apart from land) divided by the gross area (in acres).

The present value (syn. present net worth; discounted net worth) equals the net difference between discounted revenues and costs - including land costs. As this work is concerned with analyses of the same area, the land cost - if any - would have the same effect on any forest regime or species tested, and L.E.V. remains a valid basis for comparison.

TABLE 8 - 1 AREAS IN THE BAY OF PLENTY/TAUPO REGION OF COMPARABLE QUALITY TO THE MARAETAI BLOCK

Forest and Owner	Approximate area planted acres	Area available for planting in the next decade (1) acres
Tarawera; Tasman Pulp and Paper Co.	16,000	60,000
N.Z. Forest Products Ltd. (and Whakatane Board Mills Ltd.) (2)	120,000	40,000
Kaingaroa; N.Z. Forest Service (2)	100,000	20,000
Whaka; Rotoehu; Putauaki; N.Z. Forest Service	20,000	20,000
Other companies (2)	20,000+	10,000+

(1) Available - viz. already owned or leased by the afforestation concerns.

(2) Further areas of lower quality are already planted.

TABLE 8 - 2 CONVERSION OF THE THINNING WORKING CIRCLE TO NORMALITY

Operation	Regime A	Regime B	Regime C
Clearfelling of the first cycle begins at age:	30	35	42
annually covers: (acres)	500	567	370
Thinning of the first cycle, at ages 35 and 42 annually covers: (acres)	500	433	1000
Thinning of the first cycle, at ages 50 and 60 annually covers: (acres)	None	None	1000
Oldest thinned first cycle stands are felled at age:	56	56	70-76
Average age of first cycle stands at clearfelling:	43	48	56

TABLE 8 - 3 COSTS OF CLEARFELLING UNTHINNED DOUGLAS FIR

Age years	Net volume logged per acre cu.ft/acre	s.p.a.	Cost (1)	Corresponding cost used for radiata pine
	Hill Working Circle			
30	6,300	550	5.0	
35	8,900	500	4.0	7,500 cu.ft per acre from 350 s.p.a. cost 4.5 cents per cu.ft
37	10,000		3.7	
40	11,200	438	3.3	
43	12,000		3.25	
45	13,450	409	3.2	
	Thinning Working Circle			
30	6,300	550	4.25	7,500 cu.ft per acre from 350 s.p.a. cost 3.75 cents per cu.ft
35	8,900	500	3.6	

(1) Cost in cents per cu.ft.

TABLE 8 - 4 COSTS OF FELLING THINNED DOUGLAS FIR

Age years	Net vol. logged (1)	s.p.a. from	s.p.a. to	Cost (2)	Corresponding cost used for radiata pine (2)
Thinning operations					
35	3.0	500	180	9.2	2,200 cu.ft per acre from 180 to 80 s.p.a. cost 7.5 cents per cu.ft.
42	3.25	180	100	6.25	
50	1.6	100	80	5.8	
60	2.5	80	60	4.2	
Clearfelling - thinned at age 35					
41-42	9.0	180		3.25	
43	9.5	"		"	
44	10.0	"		"	
45	10.5	"		3.2	
46	11.0	"		"	
47	11.5	"		3.13	
Clearfelling - thinned at ages 35 and 42					
48	9.2	100		3.1	9,000 cu. ft per acre, of 80 s.p.a. and pruned to 36 ft cost 3.0 cents per cu.ft.
49	9.7	"		3.0	
50-56	10.2+	"		"	
Clearfelling - thinned at ages 35, 42 and 50					
56-59	11.0-12.2	80		2.9	
60-65	12.6+	80		2.8	
Clearfelling - thinned at ages 35, 42, 50 and 60					
66-69	11.9-12.8	60		2.75	
70	12.8	60		2.7	
Shelterwood - unthinned					
40	10.0	400+		4.2	

(1) 000 cu.ft per acre.

(2) Cents per cu.ft.

TABLE 8 - 5 TOTAL LOGGING AND HAULING COSTS

Age years	Logging cost (1)	Haulage cost and profit (1)	Total cost per acre $
Unthinned stands - hauler logged			
30	5.0	2.925	500
35	4.0	2.925	616
40	3.3	2.925	702
45	3.2	2.925	820
Thinned stands - tractor logged			
35 thinnings	9.2	2.925	362
42 "	6.25	2.925	298
50 clearfellings	3.0	2.925	606
			1266

(1) Cents per cu.ft.

The logging costs given above are direct costs only; they exclude overhead. The haulage costs are gross, and include a profit margin.

TABLE 8 - 6 PROPORTION OF LOG VOLUME BY S.E.D. CLASSES (1)

Log s.e.d. (in.)	Clearfelling regimes only Age (years)				Thinned stands Age (years)			
	30	35	40	45	35	42	50	Total, (2)
6 - 8	54	47	36	30	77	34	6	25
9 -12	43	43	46	44	23	63	25	32
13 -14	3	7	13	17		3	19	12
15		3	5	9			50	31
	100	100	100	100	100	100	100	100
Thinned stands, per cent of total					18	20	62	100

(1) Figures are in per cent of each categories' total volume.

(2) Viz.- total in thinned stands.

TABLE 8 - 7 SAWN TIMBER PRODUCTION AND SAWING COSTS FOR DOUGLAS FIR

Production Category			Volume	Sawing cost and profit, $	
Management Division	Age years	Log origin	(1)	Per 100 bd.ft	Per acre
<u>Frame sawing</u>					
T.W.C.	35	Thinning	14.42	3.36	486
	42	Thinning	17.90	2.26	404
	50	Clearfelling	29.37	2.05	602
H.W.C.	35	Clearfelling	44.86	2.74	1220
<u>Band sawing</u>					
T.W.C.	50	Clearfelling	32.82	2.21	726
H.W.C.	35	Clearfelling	1.72	2.21	38

(1) Total sawn volume, 000 bd.ft per acre.

T.W.C. = Thinning Working Circle

H.W.C. = Hill Working Circle

TABLE 8 - 8 TIMBER SIZES PRODUCED AND REALIZATIONS - DOUGLAS FIR

Management	One in. thick sizes(1)			Two in. thick sizes(1)		
	3x1	4x1	6x1	to 6in.	7-8in.	10in.
Unthinned						
Age 30	7½	20	2½	65	5	0
35	5	15	5	67½	7½	0
40	5	12½	5	67½	7½	2½
45	5	10	5	70	7½	2½
Thinned						
Age 35(2)	12½	25	2½	60	0	0
42(2)	5	10	5	70	7½	2½
50(3)	2½	7½	5	72½	7½	5
56+(3)	2½	5	5	72½	7½	7½
Prices (4)						
P - 1	4.85	5.85	6.45	8.20	9.50	11.00
P - 2	4.85	5.85	6.45	6.70	8.00	9.50
P - 3	4.45	4.45	4.95	6.70	8.00	9.50

(1) Per cent of sawn output

(2) Thinnings

(3) Clearfellings

(4) $ per 100 bd.ft subject to discounts of 7½ and 2½ per cent

TABLE 8 - 9 TIMBER VALUES - DOUGLAS FIR

Management	Net values (1) ∅ per 100 bd.ft			Quantity per acre (2)	Total value ∅ per acre		
	P-1	P-2	P-3		P-1	P-2	P-3
<u>Unthinned</u>							
Age 30	6.75	5.80	5.49	31.94	2,156	1,854	1,754
35	6.91	5.91	5.63	46.58	3,220	2,752	2,624
40	7.04	5.99	5.75	60.38	4,250	3,618	3,472
45	7.09	6.01	5.80	74.43	5,278	4,474	4,316
<u>Thinned</u>							
Age 35 (3)	6.43	5.62	5.23	14.42	928	812	754
42 (3)	7.09	6.01	5.80	17.90	1,270	1,076	1,038
50 (4)	7.28	6.14	5.97	62.19	4,530	3,818	3,710
				94.51			
56+(4)	7.40	6.22	6.08	68.75	5,090	4,278	4,182

(1) After discounts

(2) 000 bd.ft

(3) Thinnings

(4) Clearfellings

TABLE 8 - 10 EFFECT OF EXPORT PRICES ON REALIZATIONS

	Price levels (1)			Export
	P-1	P-2	P-3	
Original - from all sources at normality	7.10	6.02	5.81	5.22
$62\frac{1}{2}$ per cent domestic and $37\frac{1}{2}$ per cent export sales	6.40	5.72	5.59	5.22
Overall reduction in value	0.70	0.30	0.22	

(1) ∅ per 100 bd.ft.

TABLE 8 - 11 L.E.V. FOR DOUGLAS FIR, BASED ON RESULTS FROM THE FOREST ONLY, WITH ALL SALES ON DOMESTIC MARKETS

Price level	Regime	Interest rate per cent			
		4	5	6	7
		$ per acre			
Including Social Costs					
P - 1	A	173	70	18	-10
	B	190	80	24	- 6
	C	204	80	20	-11
P - 2	A	70	10	-19	-32
	B	84	20	-13	-30
	C	96	20	-16	-34
P - 3	A	44	-6	-29	
	B	58	4	-24	
	C	70	5	-25	
Excluding Social Costs					
P - 1	A	191	84	30	0
	B	212	94	36	3
	C	222	94	32	-2
P - 2	A	88	24	-7	-22
	B	102	34	-1	-20
	C	114	34	-4	-24
P - 3	A	62	8	-17	
	B	76	18	-12	
	C	88	19	-13	

TABLE 8 - 12 L.E.V. FOR DOUGLAS FIR, BASED ON RESULTS FROM FOREST AND SAWMILL

Price level	Regime	Interest rate per cent 4	5	6	7
			$ per acre		
All sales domestic - including Social Costs					
P - 1	A	214	92	30	- 2
	B	230	102	36	0
P - 2	A	110	32	-7	-24
	B	124	42	0	-23
P - 3	A	84	16	-17	
	B	98	26	-12	
- excluding Social Costs					
P - 1	A	232	104	40	8
	B	250	114	48	10
P - 2	A	126	44	4	-14
	B	140	54	11	-13
P - 3	A	100	28	-6	
	B	114	38	0	
Including 37½ per cent export sales - including Social Costs					
P - 1	B	160	62	12	-15
P - 2	B	94	24	-10	-29
P - 3	B	80	14	-19	
- excluding Social Costs					
P - 1	B	180	74	24	- 7
P - 2	B	110	38	0	-19
P - 3	B	94	26	-7	

TABLE 8 -13 L.E.V. FOR DOUGLAS FIR - REGIME B

Price level	Including Social Cost				Excluding Social Cost			
	Interest rate per cent							
	4	5	6	7	4	5	6	7
	$ per acre							
<u>Forest only - all sales domestic</u>								
P - 1	190	80	24	-6	212	94	36	3
P - 2	84	20	-13	-30	102	34	-1	-20
P - 3	58	4	-24		76	18	-12	
<u>Forest and Mill - all sales domestic</u>								
P - 1	230	102	36	0	250	114	48	10
P - 2	124	42	0	-23	140	54	11	-13
P - 3	98	26	-12		114	38	0	
<u>Forest only - 37½ per cent export sales</u>								
P - 1	120	40	0	-22	142	54	12	-14
P - 2	54	3	-24	-36	72	17	-12	-26
P - 3	38	-8	-31		56	6	-19	
<u>Forest and Mill - 37½ per cent export sales</u>								
P - 1	162	62	12	-15	180	74	24	-5
P - 2	94	24	-11	-29	110	38	0	-19
P - 3	80	14	-19		94	26	-7	
<u>Net effect of including sale of sawmill slabs for chips is to raise L.E.V. by:</u>								
P - 1) P - 2) P - 3)	16	9	5	3	16	9	5	3

TABLE 8 - 14 INTERNAL RATES OF RETURN - DOUGLAS FIR

In per cent

Regime	Including Social Costs			Excluding Social Costs		
	Price Level			Price Level		
	P - 1	P - 2	P - 3	P - 1	P - 2	P - 3
<u>Forest only - domestic sales</u>						
A	6.55	5.3	4.8	7.0	5.75	5.25
B	6.75	5.55	5.1	7.15	5.9	5.5
C	6.55	5.45	5.1	7.1	5.85	5.5
<u>Forest and Mill - domestic sales</u>						
A	6.9	5.75	5.4	7.4	6.1	5.7
B	7.0	6.0	5.6	7.4	6.3	6.0
<u>Forest only - 37½ per cent export sales</u>						
B	6.0	5.1	4.75	6.4	5.5	5.2
<u>Forest and Mill - 37½ per cent export sales</u>						
B	6.35	5.65	5.3	6.7	6.0	5.7

FIG. 1. DOUGLAS FIR. FOREST ONLY INCLUDING SOCIAL COSTS

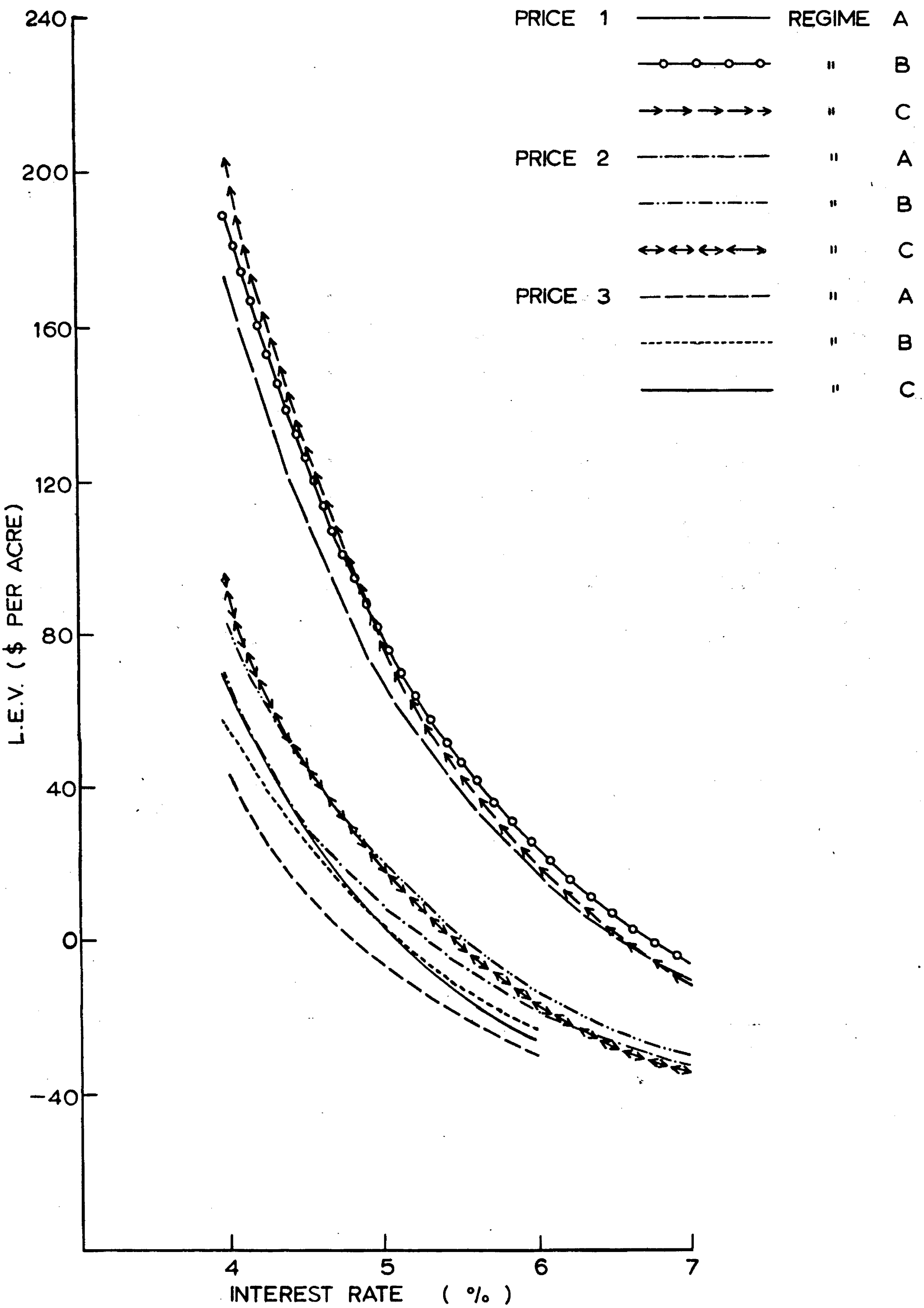


FIG. 2. DOUGLAS FIR. FOREST ONLY EXCLUDING SOCIAL COST

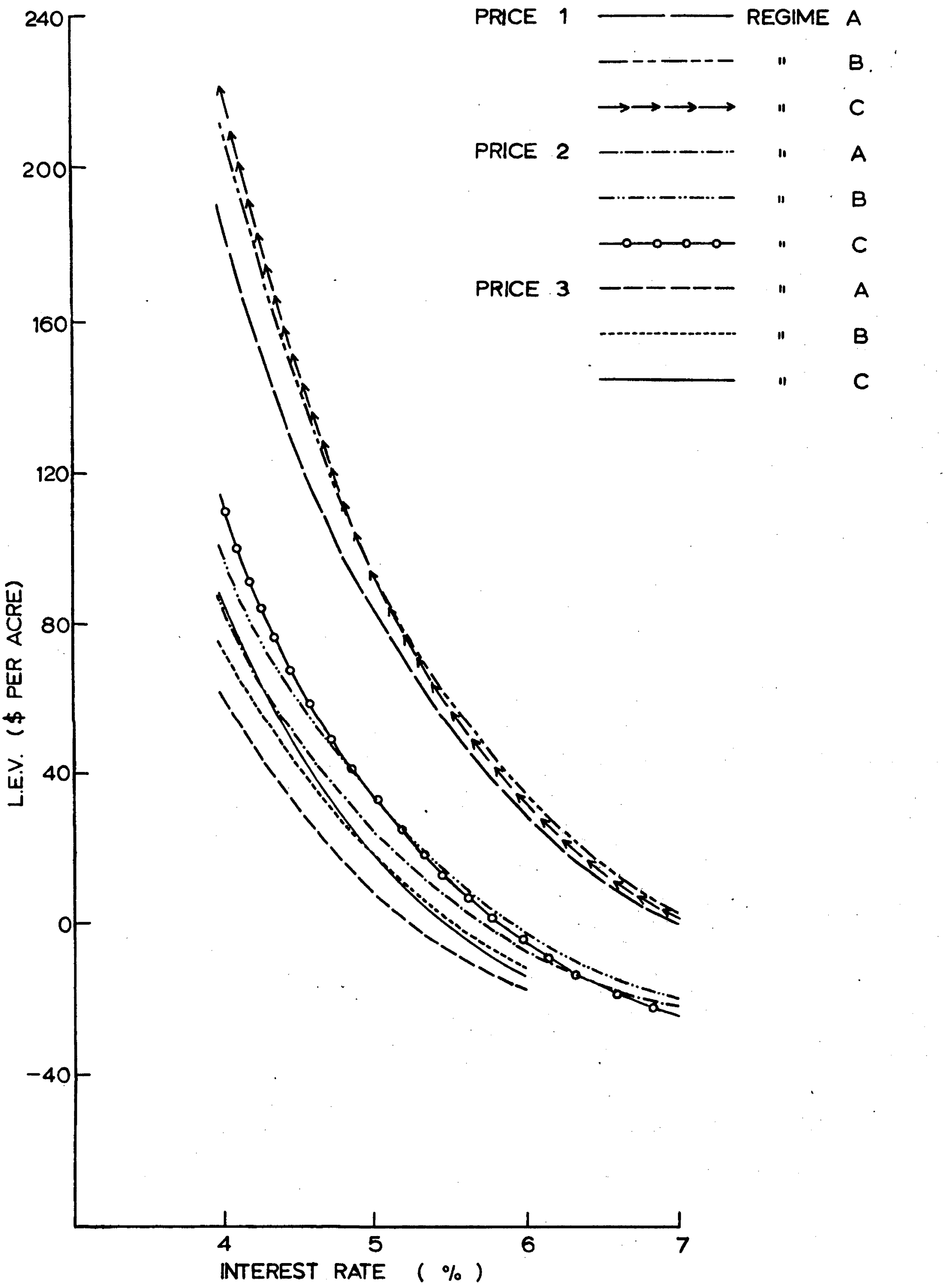


FIG. 3. DOUGLAS FIR, FOREST & MILL INCLUDING SOCIAL COSTS

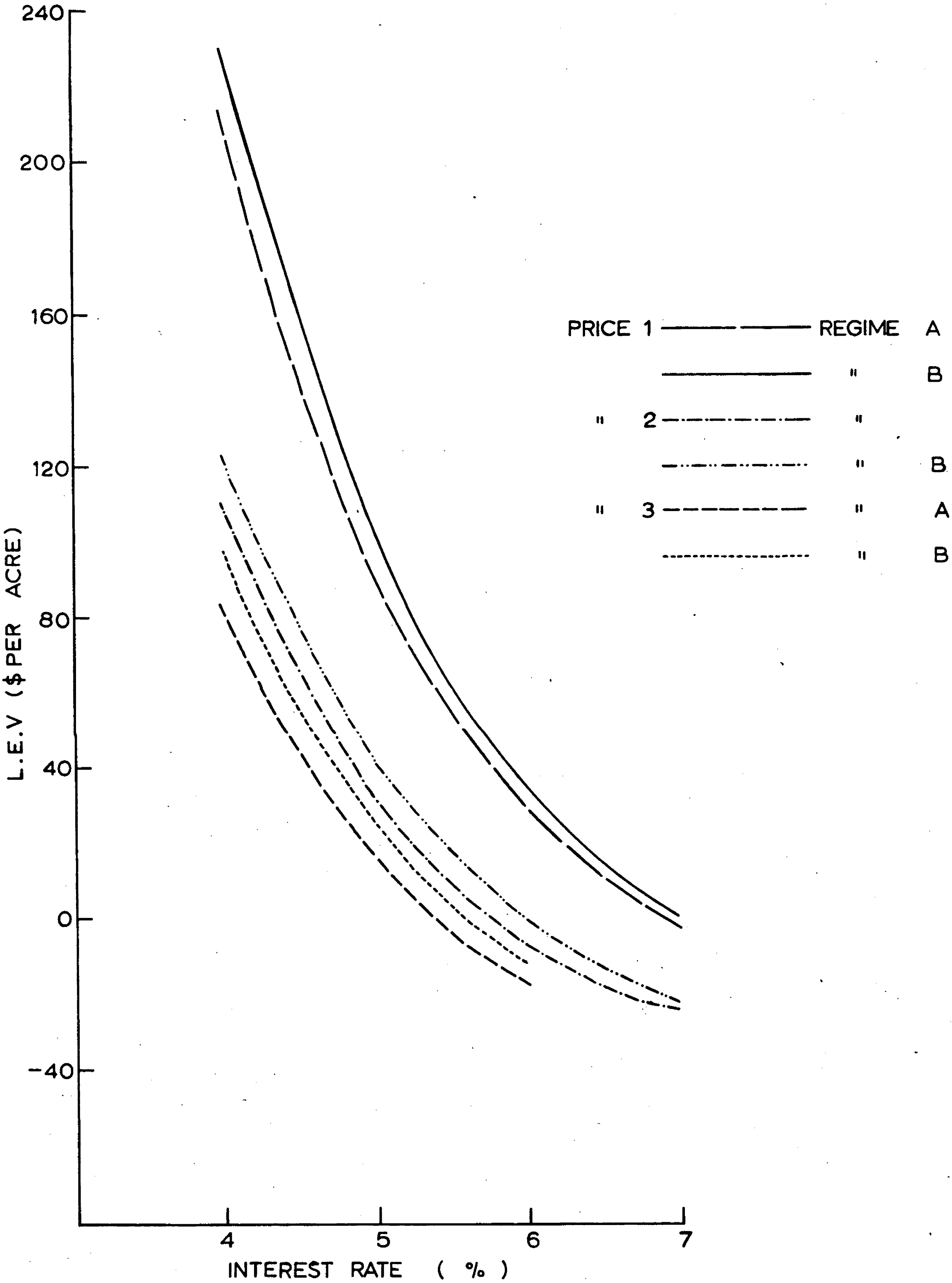


FIG. 4. DOUGLAS FIR, FOREST & MILL EXCLUDING SOCIAL COSTS

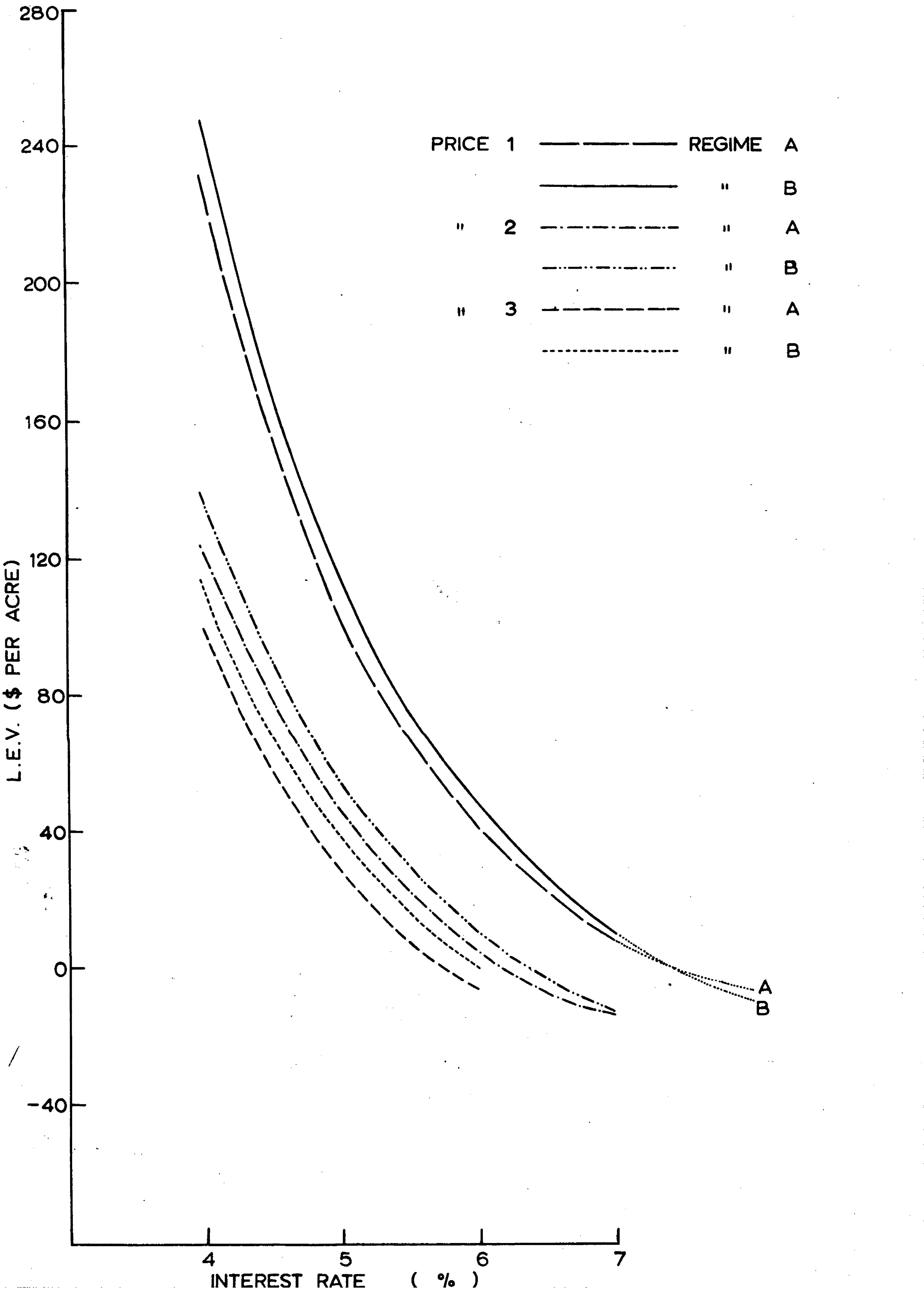


FIG. 5. DOUGLAS FIR, EXPORTS INCLUDED, INCLUDING SOCIAL COSTS.
REGIME B ONLY

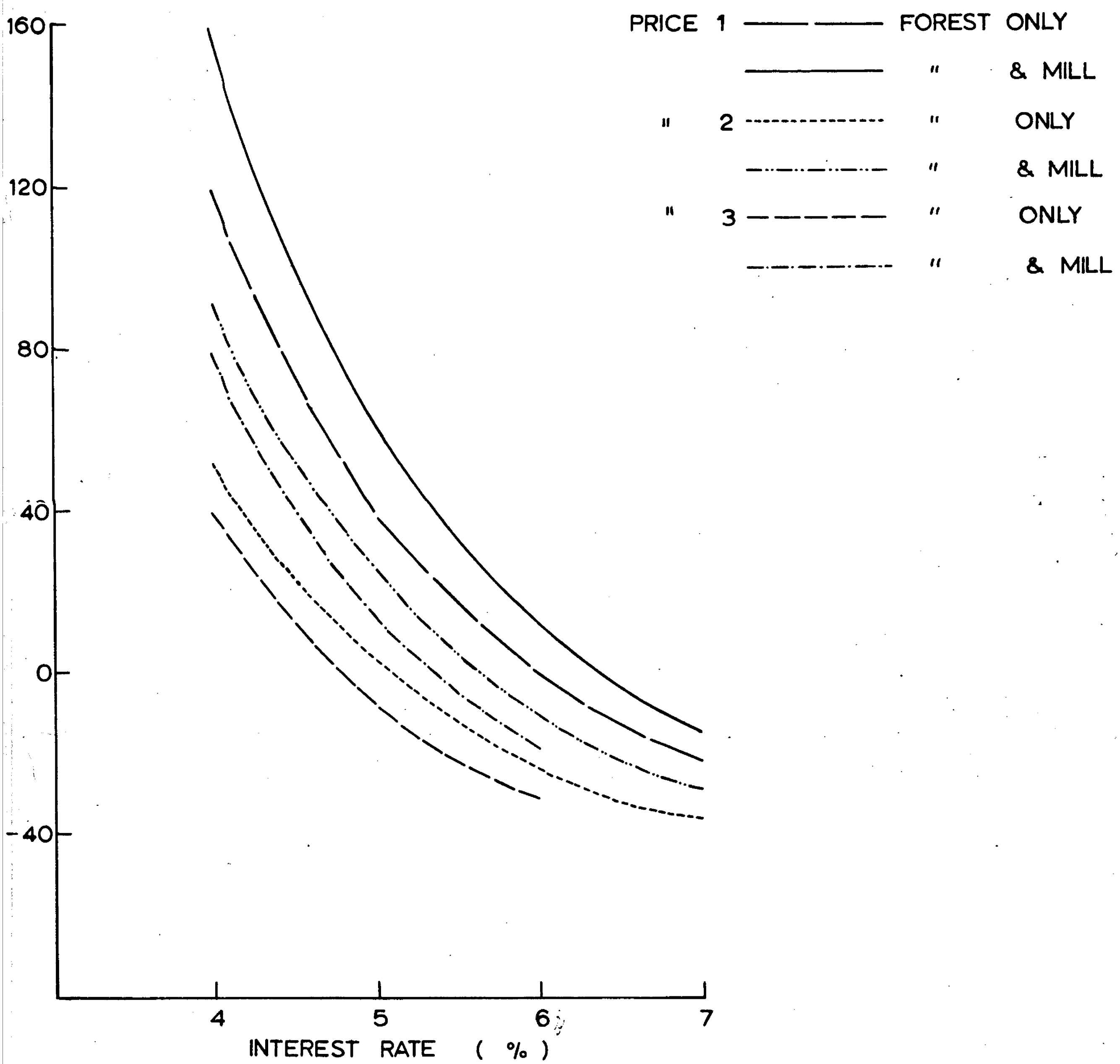
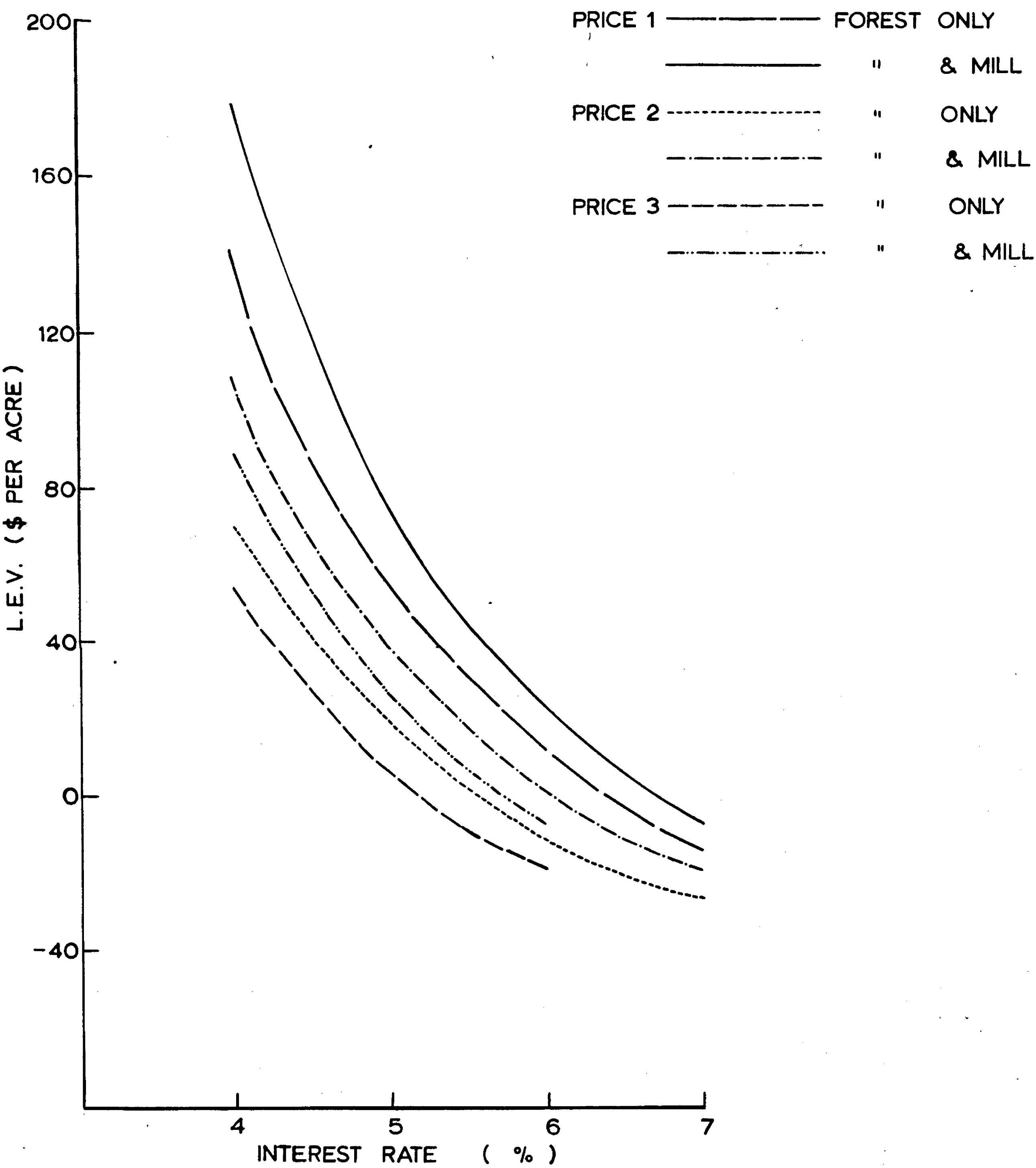


FIG. 6 DOUGLAS FIR, EXPORTS INCLUDED, EXCLUDING SOCIAL COSTS
REGIME B ONLY



CHAPTER 9 - THE PROFITABILITY OF RADIATA PINE

(a) REGIME PR I

The Maraetai study - PR I - remains the only comprehensive account published of radiata pine profitability in New Zealand (Ward et al, 1966; Fenton and Grainger, 1965). The original results, based on interest rates of four to six per cent, have been extended to eight per cent; and the forest capital at the break-even year calculated (Appendix 17). Timber realizations were based on initial results from Hull's trees, but have been amended to incorporate lower grade yields given earlier in Chapter 3 (1). Margins for clears grade of $2 per 100 bd.ft above the Dressing-grade domestic prices have been amended by a calculation (Appendix 18) back to the 'mill door' from the nearest equivalent Sydney price for radiata pine. The amended grades and prices reduce realizations by 26 cents per 100 bd.ft; the L.E.V. are summarized in Table 9-1.

The price point has been extended from a 'loaded-on-truck' basis to the end of primary manufacture. Results of incorporating sawmill capital and profit in the L.E.V. are shown in Table 9-1 (basic calculations are in Appendices 18 and 19).

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(1) Clears have been reduced from 30 to 22 per cent and Dressing and Factory grade increased from 30 to 37 per cent.

Although sawmill capital (including social costs) of $606,000 is less than ten per cent of total forest capital without interest, L.E.V. are increased by $12 per acre, or 47 per cent, at 5 per cent interest, as mill profits are higher. The effect is considerable, since all forest costs have been charged in the first L.E.V. The cost of sawing Douglas fir has been analysed in Appendix 13, and to preserve parity a reduction of 40 cents per 100 bd.ft would appear reasonable for the larger radiata pine logs (1), the effects on L.E.V. are shown in Table 9-1. The ultimate step in calculating profitability of overall forest and utilization investment is to include pulp-mill data, but the difficulty remains that a stumpage value had to be used for pulpwood production (Fenton and Grainger, 1965). In the logging operations for instance, the capital and direct costs that could be ascribed to sawlog production were incorporated in the original results, but the additional capital and direct costs for pulpwood production, though enumerated were not included as these would have already been accommodated in the residual stumpage price.

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(1) Mean diameter of Douglas fir logs is 10-12 in. s.e.d. while the mean of the radiata pine logs is 15-16 in. s.e.d.; further, 70 per cent of the pine logs are pruned.

Less comprehensive cost data are available for pulp and paper production than for sawmilling, and the figures that can be used are estimates of capital cost and a range of profits per ton of newsprint. These are based on published costs, which confirm those available privately, and are shown in Appendix 18. Pulpwood logging capital is spread over a number of years and details are given in Table A17-4 of Appendix 17. The effect of including pulpwood logging capital, and pulpmill capital and profit margins on L.E.V. are given in Table 9-2 based on calculations in Appendix 18. The results show large increases, and only at a newsprint profit of $16 per ton and an interest rate of eight per cent do values become negative when all social costs except those of the pulpmill itself are included. This result unavoidably excludes the capital and profit structure of log transport from the forest to the mills. Other omissions are allowances for working-capital in the sawmill and (probably) in the pulpmill. Against this, no increase in overall profit has been allowed for the fifteen years of increased pulpwood yields until the forest reaches normality.

The total area of forest required for a newsprint mill of 195,000 tons capacity would be six times that of the Maraetai block - 150,000 acres - if the forest regime outlined (Fenton and Grainger, 1965) was actually used. If it was entirely a pulpwood forest the area would be only 75,000 acres; as this area of 95 ft site index could produce 8,000,000 cu.ft of pulpwood annually. Simplified calculations were made of the L.E.V. at seven profit levels assuming the Maraetai area had been used exclusively for pulpwood production, details are in Appendix 20 and are summarized in Table 9-3. They show that when newsprint profits are high L.E.V. are higher for a straight pulpwood regime; as the price drops, the relative profitability of an integrated plant (viz. including a sawmill) increases. The L.E.V.'s are graphed in Figures 7 and 8.

The L.E.V. show what ultimate price the land is worth (if the log haul averages 25 miles) but the use of L.E.V. when large investments are involved gives limited information on the return to capital. The internal rates of return earned are about:

(i)	Forest regime, corrected for grade and price including social costs	5.9 per cent
(ii)	As for (i) but excluding forest social costs	6.7 " "
(iii)	Forest and utilization plants, including social costs of all except pulp-mill, pulp profit of $16 per ton	7.4 " "

(iv)	As for (iii) but with a pulp profit of $\not{\!}34$ per ton	10	per cent
(v)	Pulp production only; forest and pulpmill excluding social costs, pulp profit $\not{\!}16$ per ton	6.5	" "
(vi)	As for (v) but with a pulp profit of $\not{\!}34$ per ton	11	" "

The relative net discounted return (N.D.R.) on capital is calculated in Appendices 17 and 18 and summarised results are given in Table 9-4. In other analyses of forest profitability results for the forest (viz.excluding mills) have been calculated both per unit of discounted capital cost (D.C.C.) and at the break-even year when annual returns exceed annual costs without interest (Anon, 1966a) and the D.C.C. at the year in which the forest becomes normal, or throughout a rotation (Sinden, 1964). The former case is used where it is argued all future capital may be generated out of current income, while at normality it can be said all capital costs are bought to charge. The ratio of N.D.R. to D.C.C. depends on the definition of capital which affects the arithmetic involved. If the ratio is based on the capital to the break-even year, the discounted net returns received between then and normality are added to N.D.R. in the enumerator. If the normality year is used, these discounted net returns are subtracted from the D.C.C. and so affect the divisor. Another alternative is to keep all capital costs as gross, rather than net of intermediate returns. Relatively small alterations in the physical regime can considerably affect these ratios. Use of these ratios at least takes account of capital, but only after application of a choice of interest rates in the first place. They raise difficulties as to the definition of capital which are avoided - if only by default - by other criteria.

(b) REGIME PR II

The original results of PR I have been extended above, particularly to investigate the effect of including utilization capital and profits. In agriculture 'sensitivity to changes in <u>physical</u> parameters has not been very widely incorporated to date, but it is an area which must be included increasingly...' (Stonyer and Donovan, 1968). The earlier forest analysis specified 'the regime PR I is unlikely to be that which would yield the highest rate of financial return...it is obviously of considerable importance to investigate the financial effect of varying these proposals' (Fenton and Grainger, 1965). Regime PR II is one alternative, the fundamental silviculture of which was given in Chapter 3.

Management is simplified, regime PR II is independent of topography so there is only one working circle. Frost flats are treated as in Douglas fir regimes, with conversion to the major species - radiata pine in this case - at age 10. Establishment is completed in 11 years (instead of 17 as in PR I). Normality is achieved by prolonging some stands to age 36-38, with removal of 40 s.p.a. of the final crop 80 at age 25; details of establishment, conversion to normality and yields are in Appendix 21. Because trees of Waiotapu Cpt.28 (1) were of the same size and age as the final crop trees of PR II, realizations are based on their timber grades (Table 3-12).

A programme for an Elliot 503 computer has been prepared (Fenton and Williams, 1968) for cash-flow analysis, and results for PR II for both 1968 and 1962 costs and returns calculated. Results of PR I were also recalculated for 1968 prices and costs by this programme. Major cost and price changes are listed

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(1) Grade results are given in Table A22-4. The trees were of the final diameter and rotation age (23 to 24 in. d.b.h.; 25/26 years) specified, hence results are directly applicable.

in Appendix 22, the most notable have been the increase in export prices due to devaluation; the relative increase in price of clears; 40 per cent increase in the cost of logging machinery; and of roading. The costs of log-hauling and logging were the same - reflecting increased productivity, while timber haulage by road to port is now less than half the rail freight cost. Most other items increased by only moderate amounts. Pulp returns are constant at 3.75 cents per cu.ft net stumpage, as the prices of pulp and paper exports have not increased since 1962 (Fenton, 1968b).

L.E.V. are given in Table 9-5, and are graphed in Figure 10 for PR II (they allow full sawing costs of $\not{S}$1.90 per 100 bd.ft in 1962 and $\not{S}$1.99 in 1968). The updated results of PR I for 1968 costs and prices are graphed in Figure 11. The I.R.R. are:

	1962		1968	
	PR I	PR II	PR I	PR II
including social costs	6	9½	5	10
excluding social costs	6½	10	6	11

Results from PR II are such that they can revolutionise forestry.

(c) SENSITIVITY ANALYSES

L.E.V. results for PR I and PR II are given by broad cost and return classes (for 1968 price and cost levels) in Tables 9-6 and 9-7. Results in Tables 9-5 to 9-7 show, of course, that the final net L.E.V. and most cost components are greatly affected by the interest rate. This effect on net results appears to be almost inevitable for afforestation unless very early yields are available to offset accumulating costs in the early years of a project. Naturally as interest rates rise, those costs or returns which are incurred earliest increase in relative importance, and vice versa. The major difference between PR I and PR II is that, although PR II has higher costs throughout, due to its quicker tempo, these are more than compensated for by the early sawlog return. The crediting of pulpwood as a net stumpage results in the omission of the costs of pulpwood logging and thus in the relatively low overall clearfelling costs of PR I. As PR II has a lesser pulpwood volume, the relative cost of clearfelling is more accurately reflected than in PR I.

Social costs (and returns) are higher for PR II, as the earlier demands for accommodation outweigh the ultimately greater labour requirement of PR I. In both cases, it had been assumed that ten workers would not be accommodated on the forest; but the cost of providing houses for these men (at the rate of two per year for the first five years) is given in Table 9-8. The extra discounted cost is about Ø3 at six per cent interest and would have little effect on the I.R.R.; the L.E.V. for PR I would still be positive, though reduced to Ø9.4; PR II would still be positive at Ø19 at nine per cent interest. Social returns - rents - are of little importance (it seems debatable if hut rents of Ø4.5 a year are worth collecting). Total social costs comprise an increasing proportion of costs as the interest rate increases; in PR II, for example, social costs comprise 14.0 per cent of all costs (including social cost) at four per cent interest but 16.6 per cent at eight per cent interest. Social costs are inevitably incurred early in development and tend to be more important at high rates of interest; they can significantly affect results if they are isolated as the marginal cost near the I.R.R. of a project. Roading - the other main component of social costs - comprised less than a third of total social costs at six per cent interest in PR II (Table 9-8).

The broad cost classes given in Tables 9-6 and 9-7 can be analysed in detail, these are exemplified for PR II in Table 9-8. The discussion which follows analyses the effects of all (non-social) costs and return elements which comprise five per cent or more of total costs or returns, or which are otherwise considered to be important. Costs and returns are expressed as L.E.V. at six per cent interest (1). Establishment comprises clearing, planting, direct sowing, release cutting and blanking, and totals about 11 per cent of all (including social) costs. The total clearing cost of \$3.4 is less than two per cent of all costs, and planting costs of \$8.8 are less than five per cent of total costs. An increase of 25 per cent in planting costs would only increase costs by \$2.2.

Tending comprises slasher thinning of regeneration, other thinning to waste and all pruning operations; these total about 20 per cent of total costs. The most expensive of these operations is the first thinning to waste with a discounted cost of \$11 or nearly six per cent of all costs. An alteration of 25 per cent in this cost would alter total costs by less than \$3. Similarly, the 0/8 ft pruning step has a discounted cost of \$6.5, and an alteration of 25 per cent would alter costs by less than \$2.

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(1) 'Cost' or 'return' here means its value per acre when discounted at six per cent.

The apparently expensive capital item of logging equipment is put in perspective as having a discounted cost of $6.9 or less than four per cent of total costs. However the effect of an alteration of one cent per cu.ft on logging cost of the sawlogs (or on any further cost parameter which can be ascribed to the sawlogs once they are felled) has a more marked effect by altering returns by $11.6 or over six per cent. Hence if costs of logging sawlogs are reduced by one cent per cu.ft and log haulage costs by two cents per cu.ft and realizations rise by the equivalent of one cent, net L.E.V. will rise by over $44. The logging costs were considered to be high in Chapter 8 and a reduction of one cent per cu.ft is feasible and would increase net L.E.V. by almost seven per cent.

One component of indirect costs is protection. Dothistroma costs have been isolated and are almost equal to fire protection costs of $6.7; in other words the advent of Dothistroma has doubled protection costs, which now total over seven per cent of all costs. The cost of Dothistroma is equivalent to four per cent of the net L.E.V. The largest other single item of indirect cost is salaries at $14.8 - eight per cent of total costs, and external overhead which is nearly three quarters of the salary total. Overall, the indirect costs are probably much less sensitive to site factors than direct costs, and are more likely to be influenced by the scale of the operation. For example, Kaingaroa with, say 300,000 acres of productive forest has less than ten foresters, while smaller forests such as Hanmer often have a forester employed. Hence the smaller forests can have three times the foresters' salary costs per acre. There is no reason, however, to suppose that direct costs at Hanmer and Kaingaroa are affected by factors other than those of the respective sites.

The most important cost is that of sawmilling, which at nearly $2 per 100 bd.ft is equivalent to over $143 when discounted, if sawmill profits are excluded. The effect of including sawing with other costs is shown in Figure 12 and discussed further in Chapter 12; as sawing costs are only $13 short of the total non-social costs they dominate analysis of forest regimes designed for sawlog production. The discussion in Chapter 8 and Appendix 13 on the sawing cost of Douglas fir has already indicated the unsatisfactory basis of these costs.

Pulp logs comprise 18 per cent of volume yield at normality but only 2.8 per cent of total realizations, and the credit for sawlog slabs for chipping is only about six per cent of the net sawlog realization. This relatively small contribution has to be stressed (in analyses ending at forest ride), all that pulpwood represents is a low value component which is physically attached to the profit-making component - the sawlog. The same approach applies to the credit for sawmill slabs. In both cases the production plant - of forest-site and sawmill respectively - is in effect prepared, (at a small profit) for other operations.

The effects of one cent per cu.ft on sawlogs or of 40 cents per 100 bd.ft on sawtimber are given in Table 9-8 and provide a convenient basis for analysis of realizations. 40 cents per 100 bd.ft represents about 4.6 per cent of the average sales price of the timber produced in PR II, but the change in discounted returns is over $28. This is equivalent for example to a combined addition of 20 houses, plus a doubling of roading costs, plus the increase of planting and pruning costs by a quarter, plus full costs of <u>Dothistroma</u> protection. This juxtaposition of miscellaneous cost equivalents merely serves to stress the overall importance of changes in timber realizations in forest budgets. Changes in realizations are caused by alterations in: price; grade and size of timber sawn; and conversion factors (as well as sawing cost). The effects of alterations in some price and grade results have been analysed earlier for PR I, it is reasonable to suppose that grade outturn could be improved by choice of final crop trees on second-log characteristics (Chapter 3 and Appendix 7). If replacement of seven per cent of the 8 x 1 in. Merchantable grade by 10 x 1 in. Factory grade is all that is allowed, the effect is: a difference in price of $4.49 per 100 bd.ft in seven per cent of the timber; this is about 28 cents per 100 bd.ft and is equivalent to over $20 in discounted returns.

It remains to discuss changes in conversion factors. Those used in the original analysis (Fenton and Grainger, 1965) were based on grade study results (Fenton, 1967b) reduced by up to ten per cent to come closer to actual results in the Waipa sawmill. Subsequent studies over 1200 logs of <u>normal form</u> have shown conversion factors of:

Log s.e.d. (in.)	6	7	8	9	10	11	12	13	14
Conversion Study results	5.9	6.0	6.0	6.1	6.3	6.5	6.7	7.0	7.2
Waipa results (Appendix 14)	4.4	4.7	5.0	5.3	5.55	5.8	6.0	6.1	6.2

The studies were made on production runs over 15 different four hour shifts, spread over three months, and represent a wide range of sawing patterns and log samples. (New data for larger diameter logs are not available). The most likely explanation for the high conversion factors obtained in actual mill practice (and recorded in nearly all grade studies) is the stratification of this sample into normal - not malformed-logs (1). It is possible that the ten per cent cut in conversion factors from that recorded (over 80,000 bd.ft) in grade studies (Fenton, 1967b) is unduly severe. Each one per cent increase in average conversion factor would alter the L.E.V. by about $3.4, a change of five per cent altering L.E.V. by over $17.

The contrast in effects of changes in factors affecting realizations and those affecting other costs is illustrated in Table 9-9, where apparently small - and feasible - changes in utilization costs are balanced by proportionately severe and improbable changes in other direct and administration costs. There is an overwhelming case for concentrating further research into clarifying the sawmill end of the analysis.

The final point to be considered is the effect of production thinning on profitability. The small size and low grade of logs of radiata pine from thinnings

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(1) Viz. swept, kinked, or bent in one or more places.

has been the major reason why this material has been relatively unsuccessful as sawlogs (Tustin, 1968). These thinnings are technically suitable for groundwood pulp, however, although the relative cost of extraction and subsequent handling charges per cu.ft are higher than for larger logs. The net stumpage of 3.75 cents per cu.ft has been allowed in PR I on 2300 cu.ft net per productive acre; the net effects on L.E.V. over the gross acreage at six per cent for a range of stumpage prices are:

	3.0	3.75	4.5	net stumpage (c. per cu.ft)
If at age 18	8.3	10.4	12.4	
If at age 22	7.4	9.2	11.1	

The contribution of this thinning operation to the final discounted returns of PR I (in 1968) is $10.4 or less than eight per cent. If the full difference in L.E.V. between PR I and PR II of $155 (at six per cent) had to be made up by production thinnings then 15 operations would be required. Such a number is impossible as it is beyond the demonstrated physical growth limits of radiata pine (Beekhuis, 1966). Alternatively the return per cu.ft of the thinning operation(s) could increase, but such increases would have to be very great before PR I is as profitable as PR II. If it were possible to obtain thinnings from four operations each yielding 2,300 cu.ft net at a net profit of ten cents per cu.ft, at a mean year of 18 - all improbable assumptions - the extra discounted realization would be less than $111, for a net-on-truck M.A.I. of over 500 cu.ft per acre. This is still $44 less than the reult from PR II (1). It is evident that the real cost of the production thinning - that is allowing the opportunity cost of delayed increment on the final crop stems - is formidably high.

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(1) The pruning of the second log in PR I in 1968 has a discounted cost of $5.8 at six per cent interest, and so contributes to only a minor extent to the difference between PR I and PR II.

TABLE 9 - 1 L.E.V. FOR RADIATA PINE - PR I (1962 PRICES); FOREST SAWMILL

Category	Interest rate per cent				
	4	5	6	7	8
			$ per acre		
<u>Including Social Costs</u>					
1. Original results (1)	97.0	33.6	1.4	-15.6	-24.6
2. Results after reducing Clear yields and using export prices	84.4	26.6	-2.8	-18.2	-26.0
3. Results including sawmill capital and profit in 2	108.6	39.2	4.2	-14.2	-23.8
4. Effect of including sawmill capital and profit (3 minus 2)	24.2	12.6	7.0	4.0	2.2
5. Effect of reducing sawing cost by 40c. per 100 bd.ft	19.4	11.0	6.4	4.0	2.4
<u>Excluding Social Costs</u>					
6. (1) above	120.0	52.2	16.8	-2.2	-12.8
7. (2) above	107.4	45.2	12.6	-4.8	-14.4
8. (3) above	131.2	58.0	19.8	-0.6	-12.0
9. (4) above	23.8	12.8	7.2	4.2	2.4
10. (5) above	19.4	11.0	6.4	4.0	2.4

(1) Fenton and Grainger, (1965)

TABLE 9 - 2 L.E.V. FOR RADIATA PINE PR I (1962 PRICES); EFFECT OF INCLUDING PULP-MILL CAPITAL AND PROFIT

Interest rate per cent	Discounted capital costs (1)	(2)	Assumed gross profit, ∅ per ton newsprint 34	26	20	16
			∅ per acre			
Pulp-mill operations only (excluding forest results)						
4	88.4	6.2	504	386	297	237
5	73.4	5.2	333	255	196	157
6	61.0	4.6	230	176	135	108
7	50.8	3.8	163	125	96	77
8	42.4	3.2	119	91	70	56
Pulp-mill and forest combined (3)						
4			518	400	310	250
5			294	216	158	118
6			168	114	74	46
7			94	56	28	8
8			50	22	0	-14
Pulp-mill and forest combined - amended sawing costs (4)						
4			560	442	352	292
5			324	246	188	148
6			190	136	96	68
7			112	74	46	26
8			64	36	14	0

(1) The area could provide one-sixth of the out-put for the 195,000 tons of newsprint produced per year by Tasman Pulp and Paper Company. Costs are based on a Canadian mill of 240,000 tons per year capacity; capital cost is ∅28.6 million, or ∅190 per acre in year 20. Mill costs from Rankin, (1963).

(2) Logging capital from Table A17-4, Appendix 17.

(3) From 3 of Table 9-1; includes Social Costs for all components except pulp-mill.

(4) From 8 + 10, of Table 9-1; excludes Social Costs and allows for reduced sawing costs.

TABLE 9 - 3 L.E.V. FOR RADIATA PINE GROWN ONLY FOR PULPWOOD (FOR CONVERSION TO NEWSPRINT)

Interest rate per cent	Profit per ton of newsprint 34	26	20	16
	$ per acre			
4	822	582	404	271
5	476	322	206	119
6	280	174	96	38
7	160	88	32	- 8
8	86	34	-5	-34
9	38	0.4	-28	-29
10	7	-20	-41	-56

--- Line dividing profit advantage between 100 per cent pulp regime (upper left) and pulp plus saw-log regime (lower right).

TABLE 9 - 4 RATIOS OF NET DISCOUNTED REVENUES PER ∅100 OF DISCOUNTED CAPITAL COSTS

		Interest rate per cent				
		4	5	6	7	8
<u>Forest only</u> (producing saw and pulp logs)						
(1) Break-even year - 22						
Including Social Costs		171	78	22	-13	-38
Excluding Social Costs		283	149	69	18	-16
(2) Normality year - 40						
Including Social Costs		220	66	-7	-44	- 66
Excluding Social Costs		536	185	47	-17	-50
<u>Forest and all utilization plants</u>						
(3) Normality year - 40						
Including Social Costs (of forest and sawmill)						
	34*	439	301	213	153	109
	16*	248	158	102	64	37

* based on a newsprint profit of ∅34 and ∅16 per ton respectively.

TABLE 9 - 5 RESULTS FROM FOREST ONLY

LAND EXPECTATION VALUES FOR PR I AND PR II REGIMES

	Interest rate per cent					
	4	5	6	7	8	9
			∅ per acre			
Including Social Costs						
1962 prices and costs(1)						
Regime PR I	84	27	-3	-18	-26	
Regime PR II	338	197	114	62	29	7
1968 prices and costs(2)						
Regime PR I	145	57	12	-12	-25	-32
Regime PR II	470	280	167	97	52	22
Excluding Social Costs						
1962 prices and costs(1)						
Regime PR I	107	45	13	- 5	-14	
Regime PR II	370	222	135	80	44	21
1968 prices and costs(2)						
Regime PR I	176	82	32	5	-9	-18
Regime PR II	509	311	193	119	71	39

(1) Taking sawmilling costs at ∅1.90 per 100 bd.ft.

(2) Taking sawmilling costs at ∅1.99 per 100 bd.ft.

TABLE 9 - 6 PR I - L.E.V. BY (1968) COST AND RETURN ELEMENTS

	Interest rate	per cent			
	4	5	6	7	8
			$ per acre		
<u>Costs</u>					
Establishment	22.4	19.9	18.0	16.5	15.3
Tending	33.8	24.9	19.2	15.3	12.4
Clearfelling	27.9	16.1	9.7	6.1	3.9
Total direct (1)	84.1	60.9	46.9	37.8	31.6
Protection	17.7	14.0	11.4	9.6	8.3
Total indirect(2)	93.4	67.1	51.4	41.2	34.2
Total non-social(1)	177.5	128.0	98.3	79.1	65.8
Social	34.9	27.5	22.8	19.6	17.2
Total Costs (1)	212.4	155.6	121.1	98.6	83.0
<u>Returns</u>					
Pulplogs	79.4	55.8	40.5	30.0	22.6
Sawlogs	276.5	155.4	91.3	55.4	34.4
Total direct (1)	355.8	211.2	131.8	85.4	57.0
Social	3.4	2.4	1.8	1.4	1.2
Total returns (1)	359.2	213.6	133.7	86.9	58.2

(1) Total may not add due to rounding.

(2) Includes protection costs.

TABLE 9 - 7 PR II - L.E.V. BY (1968) COST AND RETURN ELEMENTS

	Interest rate per cent				
	4	5	6	7	8
	$ per acre				
Costs					
Establishment	24.7	22.0	20.1	18.7	17.5
Tending	57.9	45.6	37.4	31.4	26.9
Clearfelling	87.1	59.1	41.8	30.3	22.4
Total direct (1)	169.6	126.8	99.3	80.3	66.7
Protection	20.3	16.2	13.4	11.4	9.9
Total indirect (2)	98.3	72.4	56.7	46.5	39.3
Total non-social(1)	268.0	199.2	156.0	126.8	106.0
Social	43.8	34.5	28.4	24.2	21.1
Total costs (1)	311.8	233.7	184.4	151.0	127.1
Returns					
Pulplogs	22.1	14.5	9.9	7.0	5.0
Sawlogs	754.7	495.6	339.3	238.9	172.1
Total direct (1)	776.8	510.1	349.2	245.9	177.1
Social	4.6	3.5	2.7	2.2	1.8
Total returns (1)	781.3	513.6	351.9	248.2	178.9

(1) Totals may not add due to rounding.

(2) Includes protection costs.

TABLE 9 - 8 EFFECTS OF CHANGES IN SELECTED COST AND RETURN ELEMENTS; PR II (1968 COSTS AND PRICES)

	Interest rate per cent				
	4	5	6	7	8
			L.E.V. $ per acre		
<u>Cost element</u>					
10 extra houses over the first 5 years	3.4	3.2	3.1	3.0	2.9
Roading	11.0	9.2	8.0	7.0	6.2
Land Clearing	2.8	2.8	2.8	2.7	2.7
Fire protection	9.9	8.0	6.7	5.8	5.1
<u>Dothistroma</u> protection	10.4	8.2	6.7	5.6	4.8
<u>Effect of altering costs and returns</u>					
Altering planting by 25 per cent	2.7	2.5	2.2	2.0	1.9
Altering 0/8 pruning by 33⅓ per cent	3.2	2.6	2.2	1.9	1.7
Altering thinning to waste by 33⅓ per cent	7.7	6.0	4.8	4.0	3.4
Altering logging costs by one cent per cu.ft (1)	25.5	16.8	11.6	8.2	5.9
Altering sawn realizations by 40 cents per 100 bd.ft (1)	63.7	41.9	28.7	20.3	14.6

(1) Data are from the four categories of sawlogs: ages 21/23; 25/26; 35/36 and 25 year old 'thinnings'.

TABLE 9 - 9 EFFECTS OF CHANGES IN REALIZATIONS CONTRASTED WITH CHANGES IN COSTS; PR II (1968 COSTS AND RETURNS)

In L.E.V. at six per cent interest

Realization/utilization costs and returns	$	Differential in growing and administration costs	$
Logging - less one cent per cu.ft	11.6	Plus ten houses	3.1
Sawing - less 40 cents per 100 bd.ft	28.7	Doubling clearing costs	2.8
Conversion factors - plus 2½ per cent	8.5	" planting "	8.8
Realizations - seven per cent Merchantable grade (8 x 1 in.) improved to Factory grade (10x1 in.)	20.1	" pruning "	19.5
		" *Dothistroma* "	6.7
		" Salaries	14.8
		" administration vehicle costs	8.2
	68.9		63.9

cf. Total net L.E.V. 167.5

FIG. 7. RADIATA PINE. FOREST & SAWMILL SOCIAL COSTS INCLUDED

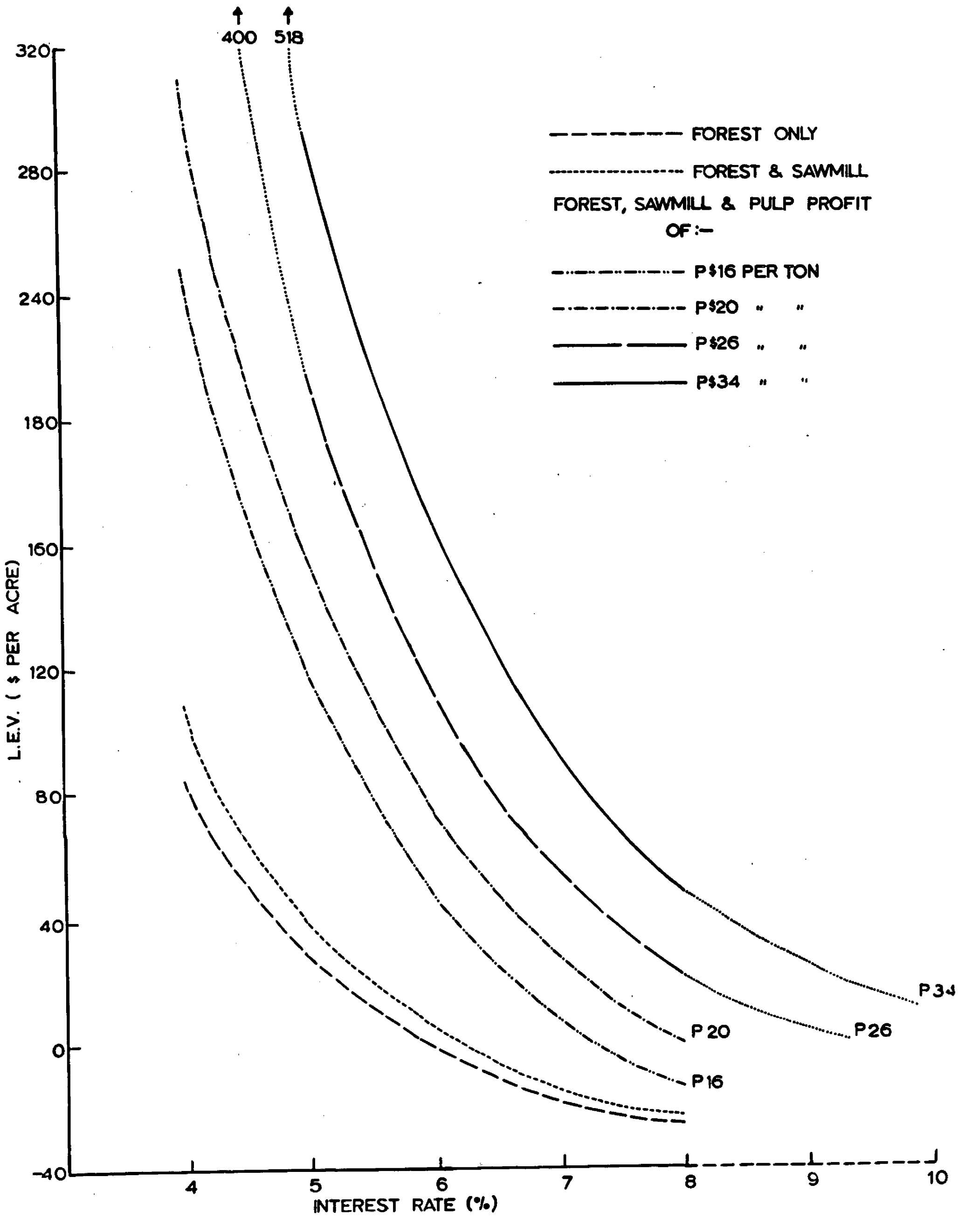


FIG. 8. RADIATA PINE, FOREST & OTHER SOCIAL COSTS EXCLUDED

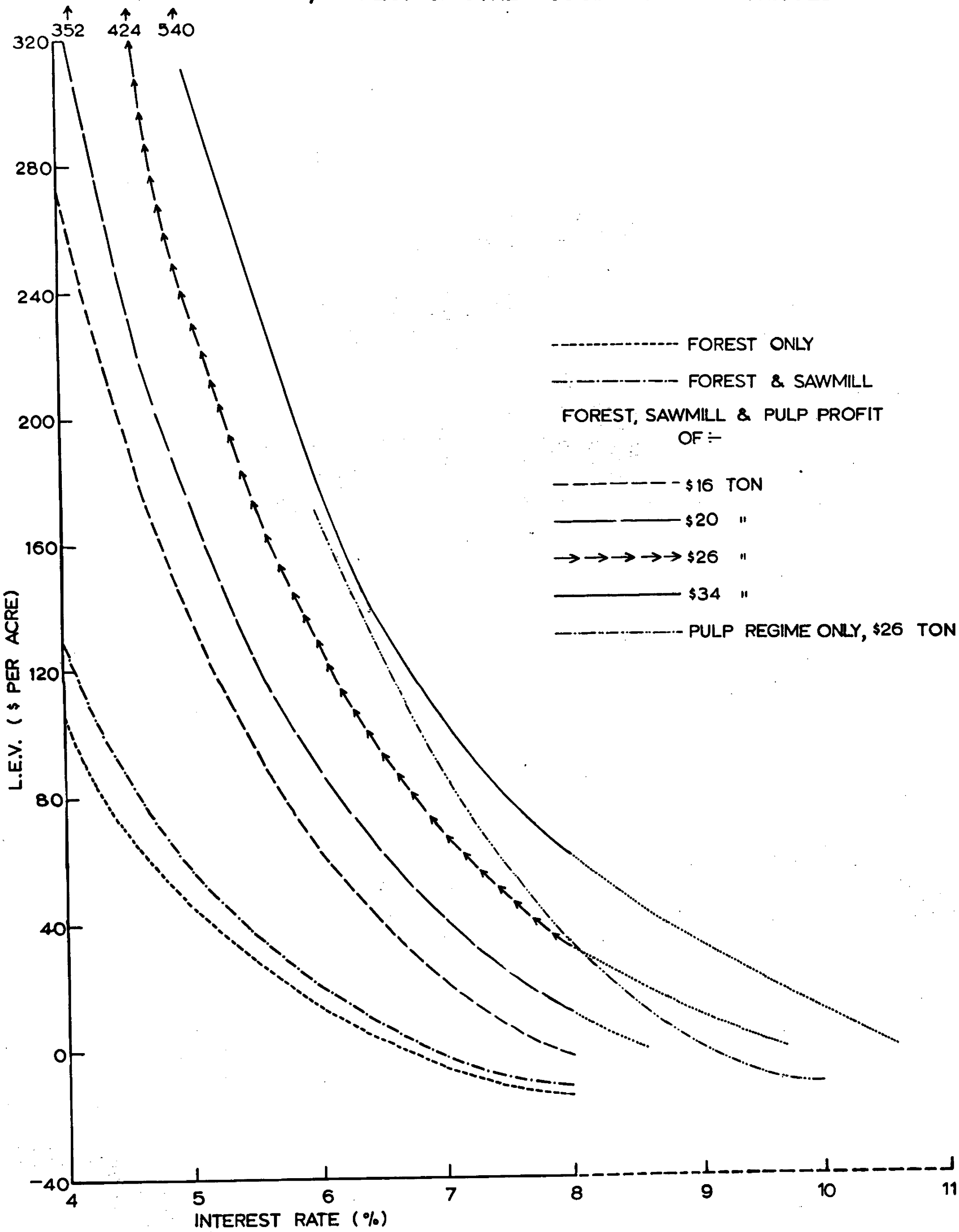


FIG. 9 RADIATA PINE, PULP PROFIT OF $26 PER TON.

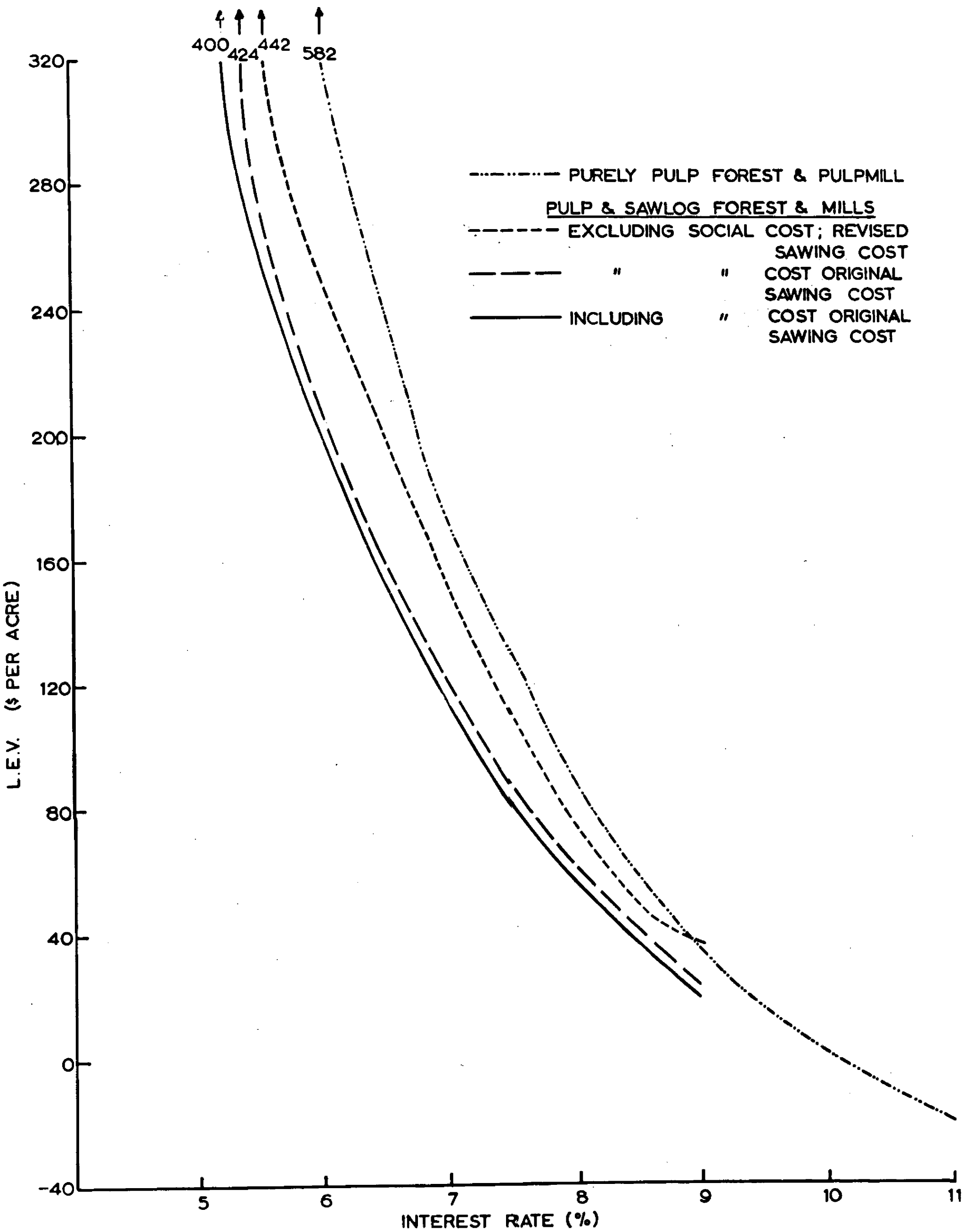


FIG. 10. RADIATA PINE - FOREST ONLY. REGIME PR II

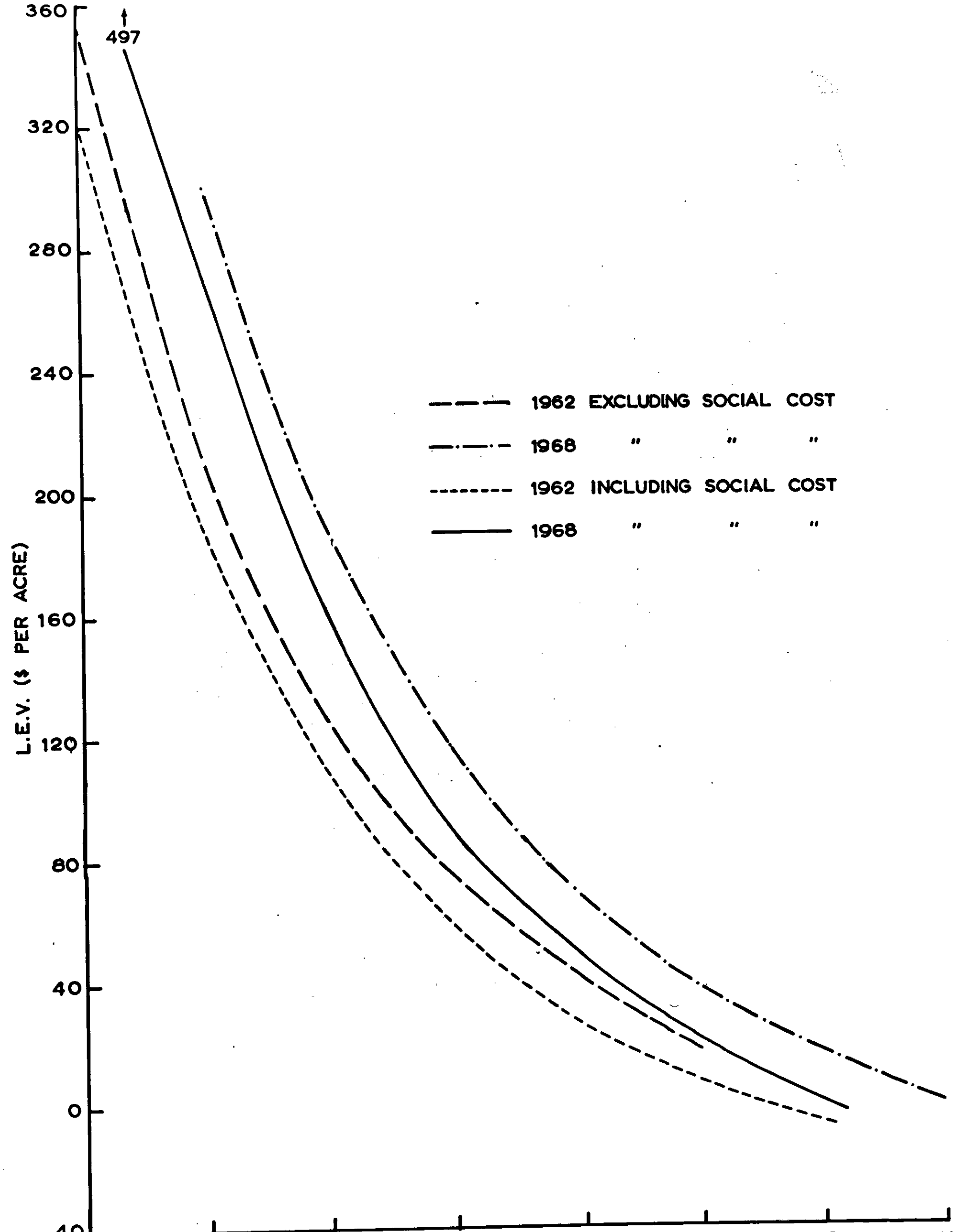


FIG. 11 RADIATA PINE. FOREST ONLY REGIME PR. I, 1968

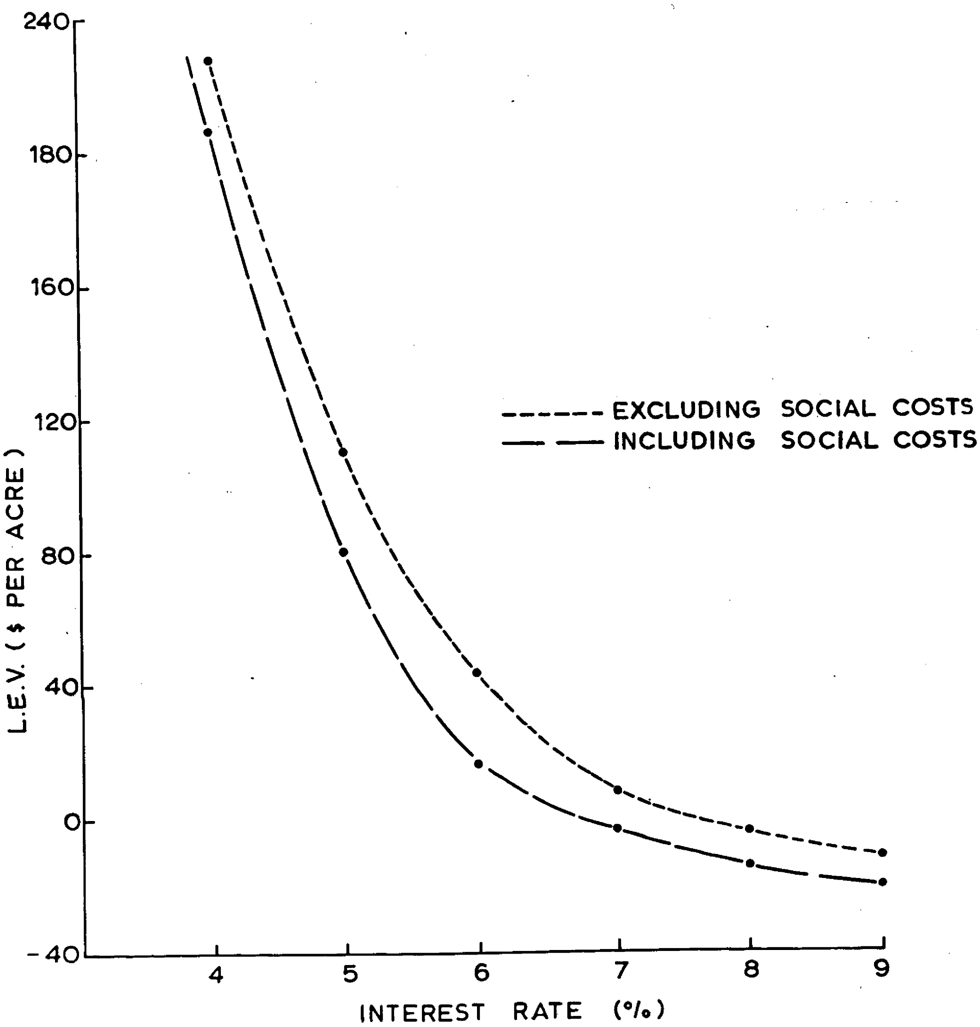
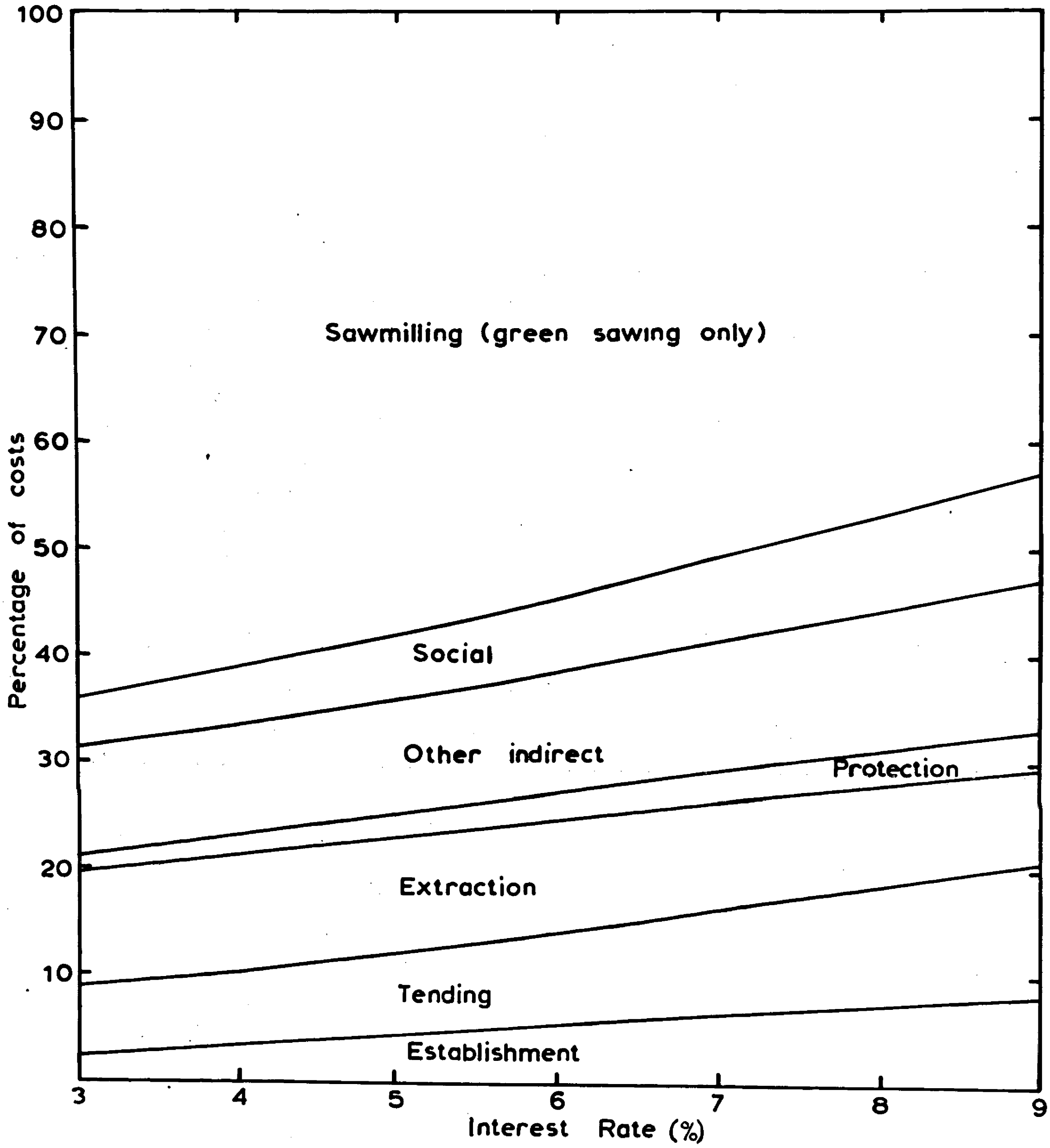


FIG 12. PROPORTION OF COSTS - EQUIVALENT L.E.V.



PART III DISCUSSION AND CONCLUSIONS

CHAPTER 10 - LIMITATIONS IN THE ANALYSIS, AND DATA REQUIRED FOR OPTIMIZING PROFITABILITY

Part III consists of three Chapters; Chapter 10 enumerates limitations in the data and the study, Chapter 11 compares Douglas fir and radiata pine and Chapter 12 deals with the role of economics in New Zealand plantation forestry and its possible effects on forest policy.

(a) PHYSICAL DATA

Errors in area statistics affect supply projections. A minor example is the rate of planting of Douglas fir, reported as 2,944 acres per year (Spurr, 1961), when the average in the preceding five years was about 1,800 acres (N.Z. For. Serv., 1956-60). The discrepancy shows the possible scale of errors in official data; similarly the marked 'drop' in area of high-pruned Douglas fir from 19,200 acres in 1963 to 13,600 in 1966 (N.Z. For. Serv., 1963; 1966) reflects inaccurate records, particularly as a direct check shows Douglas fir areas high-pruned at Kaingaroa forest alone as 15,050 acres (D.H.K. Ross, pers. comm.). Planning for a veneer plant would be on an uncertain basis on these figures. A recorded, but underrated, source of exotic timber is from private land, (that is excluding state, private company and local body tenures). Production from this source comprised 25 to 36 per cent of the exotic cut in recent years:

Year	Exotic timber cut from private land	Total exotic timber cut	Per cent of timber cut from private land
1961	142.5	395.4	36
2	124.8	381.5	33
3	115.6	375.5	30
4	117.4	395.9	30
5	119.4	472.7	25
6	142.7	507.8	28

(Source: N.Z. For. Serv., 1961-66; volumes in million bd.ft.)

These private forests comprise only 1.9 per cent of the assessed major areas of exotic forests of 50 acres and over, (unpublished National Exotic Forest Survey - N.E.F.S. - data), and presumably the timber must come largely from the 'minor' areas. The N.E.F.S. 'minor-area' survey has been checked for two conservancies and results were:

Nelson, (minimum area of any one forest three acres), the original area 29,000 acres was a 20 per cent underestimate; and for Canterbury (minimum area of any one forest two acres), the original area of 32,000 acres was a 50 per cent underestimate (N.Z. For. Serv., F.R.I., 1964). Minor areas are an important source of timber and have probably been underestimated in area by the N.E.F.S. An understandable source of uncertainty in estimates is the definition of merchantability of indigenous hardwoods, for which data are not claimed to be particularly accurate (Masters et al., 1957). Assessment of hardwood volumes of old trees is inherently difficult. Yield estimates are also subject to error. Absence of detailed yield tables for thinned Douglas fir and Corsican pine further restricts analysis. The earlier projections for Douglas fir (Duff, 1956) were shown to be too conservative (Spurr, 1963) and volume growth is likely to be greater by 12½ per cent. The volume projection used by Spurr has not been shown to be applicable to local trees, although the close agreement in tree-volume tables shown in Chapter 2 probably means the regression for volume from basal area and height he used applies.

The earlier comparison of the relative growth rate of Douglas fir and Corsican pine (Duff, 1956) underestimated the growth rate of the latter, as shown in Chapter 2.

Physical yields are affected by both stand mortality and managerial efficiency. The gross potential yield of radiata pine on the Maraetai area in PR I has been reduced to the average net yield-on-truck for Rotorua Conservancy, and only one production thinning has been allowed. Net M.A.I. has been taken as 330 cu.ft per acre, whereas the growth potential of these sites is around 550-600 cu.ft. The risks of further Sirex attack seem to be receding, but whether the reduction is unduly pessimistic, or underrates the future impact of Dothistroma is unknown. The effects of higher yields on profitability are formidable but exotic silviculture in New Zealand is dominated by the absence of profitable thinning, (apart from relatively late operations in Douglas fir) and the high physical yield potential remains unutilized. The limited areas treated (Fenton, Mackintosh and Hosking, 1965; Tustin 1968) emphasise the lack of experience of production thinning. More numerous extraction thinnings than the one operation allowed in radiata pine and the two allowed in Douglas fir could increase profitability, as yields could both increase, and come earlier. The execution of thinning prescriptions in radiata pine to date is poor, however, and the financial benefits, if any, of including further thinnings have not been allowed. Machinery and techniques for extraction thinning of less than 3,000 cu.ft per acre are not well developed, but there are no overseas examples which would allow anticipation of reduction in cost without an increase in manpower. Although the lack of profitable thinning (at top heights of 80 ft or below) dominates New Zealand exotic silviculture, it has not been acknowledged in current practice by adoption of regimes without production-thinning; the planning programme assumes long (40-50 year) rotations for all species (Williams, 1963). The prescription of short rotations, of 22 years for radiata pine, or of 35 years for Douglas fir, adopted for the hill country of the Maraetai block differs from current prescribed practice (N.Z. For. Serv., F.R.I. 1964; Bunn, 1963). The regimes PR I and A, B and C tested financially for both species over the major parts of the Maraetai block are largely adaptations of the technical prescriptions. There are no data for taper factors in thinned stands of any species in New Zealand, and log diameters and volumes have been calculated from data for unthinned stands. Similarly, for Douglas fir, sawmill conversion factors are available only for logs from unthinned stands; they are better based for radiata pine but, as discussed in Chapter 9, may have been unduly reduced in the analyses. The correlated variables of tree diameter distribution (for a given top height); tree taper and hence log s.e.d. and volume, and finally timber conversion factors are all imperfectly known for Douglas fir in New Zealand; only 'best estimates' were used in this study. The over-rigid thinning prescriptions for Douglas fir would decrease profits.

For a species with a variety of end-uses it is necessary to know the timber grades produced from different age, diameter and treatment classes. The effects of faults in techniques in grade studies, and the applicability of current sawmill results have been discussed in Chapter 3 and Appendix 5 ; earlier estimates of the extent to which national timber-grade requirements would be satisfied (Brown, 1965) were too optimistic. The aim of sawmill management should not be the maximization of grade returns, but the maximization of profits within the constraints of the log supply and market. Grade yields can be improved considerably by quarter-sawing narrow boards as against flat-sawing wides, but overall realizations decrease due to loss of width - premium and lower conversion factors (Fenton, 1967b). The timber grade data available are limited and insufficient knowledge is available, particularly from a range of tended stands, to define optimum thinning and felling regimes. The effect of absence of grading rules for Douglas fir, and the importance or otherwise of a minimum number of rings-per-inch and/or of heartwood provision remains untested. The future level of execution of silvicultural prescriptions is unknown, indifferent standards reduce profitability more for radiata pine than for Douglas fir.

(b) ECONOMIC DATA

Costs for many operations depend on environmental conditions and the appropriate costs to use are often still poorly known, but the biggest gaps are for utilization operations. The range of logging costs used in this study is pivoted on the final clear-felling cost of tended radiata pine, which appears to underestimate the cost-reducing effects of early tending.

The great influence of shifts in plantation log-size on overall profitability, when utilization involves gang mills, has been demonstrated (Fenton and Brown, 1963). The least-cost solution for growing and milling plantations depends on the break-even point between accrued growing costs, principally interest charges, and reduction in net logging and milling costs due to increasing log-size and timber realizations; the whole is influenced by increasing net productivity per unit area from stands of increasing age. The overall importance of sawing costs in the analysis of plantation profitability is insufficiently acknowledged, primarily because the majority of studies adopt a given range of log prices, usually 'at-stump' or 'on-truck', which take the effects of utilization costs as read. As an indication of their importance, in stands grown wholly for sawlogs and with overall conversion factors of 5.5 to 6.0 current sawing costs amount to 12c. per cu.ft, compared with haulage costs of around 3.5c., clearfelling costs of three to five cents and growing costs of seven to ten cents. In regime PR I, for example only 240 large logs are sawn per acre and annual sawmilling costs at normality are Ø380,000 compared with total annual forest costs of Ø260,000.

The effect of sawmilling costs, when discounted, has been discussed in Chapter 9.

The most profitable solution to the multiple problem of growing and sawing purely saw-log forests is to design the optimum mill for the size-range and volume of logs available at any age. This, in turn, depends on the forest area and the thinning regime, and haulage costs are usually the ultimate limiting factor. The choice of mill equipment and size, and correlation with forest size and treatment remain open fields for decision due to lack of data, yet one fundamental advantage of plantations is that suitable planning can optimize results.

The desirability of accurate biological and managerial data was discussed by Dowdle (1962), who pointed out that while better data could improve efficiency, their benefits could be nullified by errors in demand forecasts. The timber market has been under two distorting influences over the last three decades: both the domestic prices of most home-produced timber and the volume of timber imports has been controlled. Price controls were lifted in 1966, but the appropriate margin in price between grades and between species has not been market-determined in the past. Market demands have probably been unduly inflated by the relative abundance of high grades from the indigenous softwoods, sold at controlled prices. As prices were low in comparison with those of comparable board grades in North America, for example, they may rise now but the extent of any relative future increase in price of high grades of boards in comparison with Douglas fir framing is problematical. Thus there are additional complications leading to the inevitable uncertainties involved in any future market projection, which include the unknowns of population numbers, taste, substitutes and technological developments.

In contrast to the limitations imposed by risk or uncertainty, or the restrictions in the physical or financial data, the differences shown by the formal investment criteria are more easily accommodated. The theoretical failings of the I.R.R. are not a problem in these analyses of plantation forestry and the rate of profit earned is a useful indicator to use for within-forestry comparisons. The traditional L.E.V. form of present net worth used in forestry is still a good indicator of profitability, particularly as expansion programmes require land acquisitions. The limitations of L.E.V., as shown in Chapters 5 and 8 are the absence of recognition of the capital inputs required, the omission of cost-of-land and, if values are negative, the possibility of anomalous results with increase in interest rates. Use of ratios based on discounted costs and returns at various points in time does not overcome the capital input difficulty, and further, these ratios are sensitive to definitions of what is cost or return. The best criteria to use appear to be those which are most intelligible to the decision-maker concerned. The budgeting approach, which defines labour and capital inputs over time, together with summarised results in the form of L.E.V. and I.R.R. is practical, utilitarian and as theoretically sound as any, and the cost of land, if any, can be easily allowed for when the L.E.V. is found. Of more importance than the criterion to use is the decision on where analysis is to end - e.g. at stump, on ride-side, on truck, at mill skids or after primary or secondary manufacture. The traditional point at stump derives from the role of a forest service charging timber royalty for the right to exploit otherwise free raw materials; but there are no logical reasons why this end-point should always apply. The decisions on price-point must be empirical, and by taking the end of primary manufacture, (which is usually allowed for in the calculations of royalties in any case) the benefits of mill profits are included. The analysis excluded the capital costs and profit margins of log haulage (as data were unavailable) and so were not fully comprehensive.

(c) CALCULATING PROFIT IN PLANTATIONS

Many of the data needed for calculating profit have been given, inter alia, in the preceding discussion on study limitations and have been summarized elsewhere (Fenton, 1967c). The range of data required for a given area and country are summarized below:

(i) Physical data

(i)-1 The relative and actual site indices of the species for possible afforestation; allowances for the original vegetation and the presence of noxious animals.

(i)-2 Topographical/soil survey (1) to find the proportion of land workable by wheeled/tracked tractors.

(i)-3 Yield data for the species, including the log size assortment at any age, for any espacement and thinning regime.

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(1) Soil type, as well as topography, needs to be known as it may preclude use of tractors - e.g. clay at Maramarua; swamps in Westland.

(i)-4 Grade yields and technical limits for timber and pulp from all of the production possibilities of (i)-3 (Largely data on crown development and death).

(i)-5 The efficiency of silvicultural operations - e.g. degree of failure in planting, and of attainment of management prescriptions; logging losses by age, tree diameter and height.

(ii) Economic data

(ii)-1 Costs, and labour content, of direct forest operations.

(ii)-2 Costs of housing, roading and all indirect costs.

(ii)-3 Relative costs, and labour content, of different logging methods and intensities.

(ii)-4 Costs of sawing by mill types; mill capacity required integrated with (i)-3 and (i)-4 above.

(ii)-5 Costs of transport.

These local data would have to be assessed within a national demand context for particular products over time, and beyond this to allow for varying levels of imports and/or exports. Once comprehensive ranges of data were available for (i)-2 to (ii)-5, management of a given area could be optimized by linear programming techniques for given end-use constraints, but this could only be possible after a most formidable research programme had supplied the data required. Some idea of the work required can be gained by the work-content and cost of obtaining the grade, and tree size and volume data for 26 year old radiata pine from Waiotapu Cpt.28 used in the PR II projections of Chapter 9. Total work exceeded 400 man-days and the cost was over $3,000.

The physical and cost data listed above can be found eventually with sufficient research. Despite the obvious imperfections of the data it is possible that the details available for New Zealand plantations are more comprehensive than from other countries, due to the range of results available from the first rotation, the high growth-rate (reducing the time in which experimental results become available), and the costs from State utilization operations. The approach in this study has been to illustrate the difficulties involved in what is an apparently simple problem - how to determine the profitability of plantations, exemplified by radiata pine and Douglas fir.

CHAPTER 11 - COMPARISON OF DOUGLAS FIR AND RADIATA PINE

(a) INTRODUCTION

The general appearance of established Douglas fir stands in New Zealand is attractive, tree form is generally good, stocking full and growth rates high. It attracts strong support from visiting authorities: 'Why not more use of Douglas fir on sites to which it appears to be well adapted?...other things being equal (here I [Zobel] must confess ignorance of the situation) I would certainly stress this species equally with radiata pine.' (Zobel, 1965). And '...the quality of timber is so much better than that of radiata pine that much higher stumpages can be expected'; further 'the Australian market may well be expected to absorb all the Douglas fir New Zealand can export' (Spurr, 1961). Elsewhere the inability of Douglas fir regeneration to supplant that of radiata pine on clear-felled areas was deplored, and the limitation of Douglas fir to less than ten per cent of the State exotic forest area was termed a 'tragedy' (Muir, 1954). The reasons for the present favourable stumpages for Douglas fir have been analysed (Fenton 1967a), in summary they are: practically all the timber produced has been from delayed thinnings of 40 year or older stands and maintenance of dense stocking has been ideal silviculture for the major end-use as framing timber; the expensive-to-saw small logs have been diverted to a profitable round-produce market, which technical and commercial developments have now opened to pines; only two to five per cent of the exotic softwood cut has been of Douglas fir, which has been sold ungraded and without price control; the stands thinned profitably have been on easy topography; and finally, the species good name, the lack of imports and its own good qualities as framing timber increased profits.

Resolution of the true relative profitability of radiata pine and Douglas fir is needed to guide policy. Their respective worth on the Maraetai blocks which, as shown in Chapter 2, represent the average site quality for North Island Douglas fir, has now been calculated; comparisons of their management and profitability are made below.

(b) END-USES

The differences in end-uses between the species have been given (Reid, 1953; 1962; 1963; Fenton, 1967a) in Chapters 2 and 3. Basically the contrast in specific gravity of over 100 per cent between the late and early wood of an annual ring in Douglas fir

(Harris and Orman, 1958), when combined with a growth rate of seven rings or less to the inch, results in inequalities of texture which are too great for generally satisfactory performance as dressed timber. The even-textured, slow-grown imports of Select grade Douglas fir which do find outlets as interior-joinery timber cannot be produced (except by a combination of long rotations, pruning and high stocking) by New Zealand plantations. The predominant outlet for exotic Douglas fir is framing timber. Radiata pine by contrast, can produce good quality finishing timbers at high rates of growth if properly tended, but as the majority of stands have remained untended, its major domestic outlets as timber have been for framing and low-grade boards.

Round produce - primarily posts and poles - is only a minor market, the total of 7.9 million cu.ft produced in 1966 being about four per cent of the exotic log cut (N.Z. For. Serv., 1966). The annual total already exceeds the five million cu.ft forecast for the year 2000 (Grainger, 1961) largely because of favourable tax incentives for farm-fencing programmes. Pine is readily treated with water-soluble preservatives while Douglas fir requires oil-soluble treatments.

As a total of over 200 water-soluble-treatment, and only three oil-soluble-treatment plants are in New Zealand, pine will inevitably obtain a greater share of the market. The seasoning difficulties of the pines are being circumvented by new preservation techniques, and the deeper preservation achieved in pines may outweigh disadvantages of poorer form. The total market is relatively small, although likely to increase forest profitability where sales can be made. The relative merits of the two species for round produce are summarized elsewhere (Fenton, 1967a).

Differences in pulping characteristics are more marked, radiata pine being superior for groundwood, semi-chemical and chemical pulp. The dry, coloured and extensive heartwood of Douglas fir results in high cost of production, but sappy slabwood from sawlogs is satisfactory for kraft pulp, and for refiner groundwood.

(c) SILVICULTURE CHARACTERISTICS

The differences in silvicultural characteristics of the two species are summarized in Table 11-1. The ability of Douglas fir to bear laissez-faire management frees it from such exigencies as shortage of funds in any one year. It is more suitable for steep sites, where tending is expensive. Differences in treatment are summarized in Table 11-2.

The extent of pruning in State forests is given in Table 11-3. The pruned stems per acre usually number 80 to 110 or more. The published figures include errors, exemplified by Douglas fir and discussed in Chapter 10, further data are in Table 11-4. The area of 0/18 ft pruning for all species is given as 87,601 acres in 1966, whereas annual acreages from 1943 total 98,890 acres; the area clear-felled would not account for the difference.

The location and year of pruning allows its future contribution to timber grades to be assessed, and details for radiata pine are given in Appendix 23.

The conclusions are:

(i) Less than 20,000 acres of this total can be expected within 30 years to yield clearwood approaching that of Hull's trees and most of this acreage has been pruned only since 1960.

(ii) A further 6,000 acres of Southern pines and 15-20,000 acres of radiata pine has been pruned late enough for knotty cores of 10 in. or more to develop. Clear yields will be much lower than from Hull's trees, but considerable yields of Factory grade will accrue in the next 25-30 years.

(iii) The balance of the pruning was either so late or of such slow-growing species, or of Douglas fir, that even modest yields of clear pine timber cannot be anticipated for at least 40 years.

These results are poor, and the reasons for these misplaced efforts and the resultant loss of high-grade potential need brief examination, if only to check if errors of this scale are likely to be repeated in the future. In a decentralized and geographically dispersed organization, occasional silvicultural errors, such as the far-belated pruning of 40-year-old Corsican pine on mediocre quality sites, will probably occur. This unfortunate operation became general policy in many parts of New Zealand from 1946 until recently as part of a reaction against the lack of any extensive tending in the preceding years.

'In any attempt to secure quality...New Zealand is faced with the need to embark, even at this late stage, on a large-scale high pruning programme. In many cases, the trees will be past the diameter limits normally adhered to and the operation will be hard to justify by past concepts of pruning economics. Nevertheless,

> to ensure quality production in 20 to 30 years time, high pruning must be carried out' (Thomson, 1952).

Slightly later it was stated: 'with a few exceptions, silvicultural operations have been carried out at a heavy net charge against the forest. Little attempt has been made to justify the expenditure by speculative estimates, of the (subsequent)...improvement.' (Entrican, 1957). Even simple analysis was omitted and little order of priority is evident in the 15 years of pruning up to 1960. The worst aspect of this misplaced activity was the lack of pruning on young stands of radiata pine which were often available in the same forest, and certainly nationally. Although the release of grade study results on 'élite' stands in 1958 and 1959 helped, at least to relegate Douglas fir priority below that of pines, much poorly conceived and executed pruning continues. Only after a Forest Research Institute symposium on thinning and pruning (Bunn, 1963) were the principles of pruning more properly applied. Up to 1963, only $22\frac{1}{2}$ per cent of the area 0/18 ft pruned was of radiata pine.

Much current pruning in State forests is still of negligible value. For example, Corsican pine is relatively slow growing (Appendix 2) and the Nelson area is of lower site quality than most North Island sites (Hinds, 1955). Yet the extent of 18/36 ft of pruning in Nelson increased by one half in 1967 (N.Z. For. Serv., 1967), and the area of Corsican pine 18/36 ft pruned there is twice that of radiata pine. As the Corsican pine in Nelson is now (1968) to be exported as pulpwood chips, the 0/18 ft or higher pruning of over 5,000 acres there is largely futile. Similarly, 1200 acres of radiata pine have been 18/36 ft pruned in Ashley forest (150 acres in 1967) where the local phenomenon of resin-pockets effectively prevents use of timber for high-grade boards. While the latest Working Plan revision (B. Swale, pers. comm.) prescribes cessation of the 18/36 ft operation, 0/18 ft pruning is allowed to continue, although resin pockets are equally numerous in butt logs. Over 2,500 acres are 0/18 or 0/36 ft pruned at Ashley (640 acres in 1967) so that more than $140,000 of direct pruning cost (without interest) has been incurred for very doubtful returns.

(d) DIFFERENCES IN LABOUR REQUIREMENTS

The labour required at forest normality is little different for the two species, though the work content and relative skills differ. The requirements differ in the higher numbers required for pruning and the lower numbers for production thinning radiata pine. Details are summarized in Table 11-5 for the Maraetai block of 25,000 acres. Numerical differences in managerial staff are unimportant; while more supervision is required for the pruning programme of radiata pine, the more extensive production thinning of Douglas fir in turn requires more staff. The relative appeal to labour of production thinning work against thinning-to-waste and pruning is conjectural, though as the attractiveness of 'bush-work' still remains, there is an advantage for Douglas fir, counterbalanced by the greater hazards of the work.

The critical difference is in the technical level of supervision required. Formal prescriptions have been made for both, but as long as thinning is delayed until age 35, the timber-qualities of Douglas fir will remain relatively unaffected by considerable variations in the thinning schedule. By contrast, the pruning and thinning prescriptions <u>must</u> be adhered to for radiata pine if grade yields are not to suffer. The evidence from pruning shows the level of management required is hard to attain, and there is therefore, a higher risk of failing to achieve the objects of management for radiata pine. Accurate standards are easier to achieve in thinning to waste than production thinning, and so risks are less for PR II than for PR I.

(e) ECONOMIC DIFFERENCES - FOREST BUDGETS ONLY

The economic differences depend on the particular set of assumptions made for each species. The first basis for comparison is for current prices for Douglas fir, and with the price point as 'loaded on a truck'. A decision is required whether to include social costs; these are higher for radiata pine as they are incurred earlier. For within-forestry comparisons, and certainly for the narrow comparison of which species should occupy the same site, social costs should be included. At 1962 domestic prices, the L.E.V. for Douglas fir for all three regimes tested are absolutely greater than those for radiata pine at PR I - whether a reduced sawing cost is allowed for the latter or not - for interest rates of four to seven per cent. The I.R.R. for Douglas fir is $6\frac{3}{4}$ per cent, and for radiata pine, six per cent. This result assumes all Douglas fir sales are domestic and future prices will maintain the same relativity. The comparison is unfair since it excludes both credit to Douglas fir for pulping sawmill slabs and consideration of exports. The effect on the I.R.R. of including slab credit is of a rise of only 0.1 to

0.15 per cent for price levels P1 to P3 for Douglas fir. PR II results are vastly better than either of the others. The effects on L.E.V. of including the same proportion of export produce from Douglas fir as from radiata pine are more pronounced:

L.E.V. ($ per acre, including social costs, and slab credits)

	Interest rate per cent			
	4	5	6	7
Douglas fir - regime B				
Price level 1	136	49	5	-19
2	70	12	-19	-33
3	54	0	-26	
radiata pine				
PR I	84	26	- 3	-18
" - lower milling cost	104	38	4	-14
PR II	338	197	114	62
" - lower milling cost	402	239	143	82

If a 40c. per 100 bd.ft lower milling cost is allowed for radiata pine, and domestic prices apply to the remaining unexported Douglas fir, the effect is to make Douglas fir more profitable than PR I at four and five per cent; no real difference at six per cent and radiata pine less costly at seven per cent; the I.R.R. for both would be about 6.2 per cent. At lower domestic prices for Douglas fir, whether any is exported or not, radiata pine, even in PR I, is absolutely more profitable, whatever adjustments are made for slab pulping, social cost and reduced sawing cost. (The only exception is for regime C at four per cent, with P2 realization and including social cost).

One of the significant parameters is the appropriate price level to use as stressed in Chapters 8 and 9. The 1962 radiata pine results were based on controlled prices for all grades except Clears; the latter were priced on a (lower) export basis. The relative domestic and export prices (Table 11-6) of radiata pine, show variations for grade and width which reflect the relative demand for the respective grades. The two price lists are generally comparable for radiata pine, but as has been shown in Appendix 15 the domestic price of Douglas fir is above the average price obtained for exports. This may be due to the export of a higher proportion of boards, as against framing, but no data were available on the sizes exported, and the assumption has been made that the average outturn of sizes was exported.

The other basis for comparison is the price of Douglas fir imports. The average f.o.b. prices for 1959-65 (Fenton, 1967a) are:

	U.S.A. to		Canada to	
	Australia	New Zealand	Australia	New Zealand
Average price $ per 100 bd.ft	7.32	7.35	5.64	6.87
Total quantity million bd.ft	475	27	657	11

The imports still entering under licence are largely of grades which are unavailable from the exotic resource (J. S. Reid pers. comm.) and the fairest equivalent price of the qualities produced in New Zealand is the Canadian cost to Australia. With sea-freight of $2.60 per 100 bd.ft, the duty-free price at Auckland, excluding landing costs, would be $8.20 per 100 bd.ft. The equivalent mill price on the Maraetai blocks of $8.20 per 100 bd.ft at market would be less $1.30 rail-freight, or $6.90 per 100 bd.ft. The domestic price list (P1) gave an average realization at mill of $7.10, so the domestic price of Douglas fir is reasonably close to the duty free price of equivalent imports.

The greater the proportion of Douglas fir exported, the lower the return, until realizations are below those at P3 level, where the I.R.R. drops to $4\frac{3}{4}$ per cent for regime B. The radiata pine prices, by contrast, are little different, and if all timber was exported and saleable, the I.R.R. would still be nearly six per cent, even for PR I; it is over nine per cent for PR II. As recently as 1965 Douglas fir timber comprised only five per cent of the total exotic cut in New Zealand and it has a scarcity value on the domestic market. This, combined with its great name, has resulted in a favourable price structure. Radiata pine and the indigenous softwoods have been subject to price control, and the result has been a relatively narrow spread of prices through the grades. Price control was lifted in 1966 with little marked effect to date on exotic timber prices. If prices of low grade timber fall, the effect on the Maraetai radiata pine results will be small, as the overall grade outturn is high. Conversely, if prices of high grade timber increase, results will improve. The future timber supply in New Zealand will be almost exclusively of exotic softwoods. The final depletion of the indigenous softwood forest can be calculated: nearly 20 per cent of the remaining resource - 484 out of 2,453 million cu.ft (Masters et al, 1957) - was sawn in the decade to 1966. Indigenous supplies from State forests are being restricted, and could sustain a much reduced cut for rather more than 40 years but the resource and its attrition are accurately known and only small quantities will be available after 2010. The indigenous softwoods yield about half their total volume in finishing grades, (predominantly clearwood); such grades can only be replaced as timber by radiata pine, not Douglas fir. As a conservative estimate, the future price structure should show a relative improvement for the high grades of boards obtainable from pruned radiata pine. In contrast, relatively abundant framing timber will be available from the remaining, untended 'first-crop'; stands which have not received optimum tending - especially those on steep sites; and from the eventual clear-felling of Douglas fir. If timber retains an appreciable market, the future supply position must favour tended radiata pine, rather than Douglas fir.

Another indicator of the possible timber price differential is that in North America, where the pines have marked advantages as they provide finishing, and not structural timbers (Reid, 1953; Fenton, 1967a).

Thus indications from the export prices, from the future supply situation, and from North American prices, support the same conclusion: a relative increase in the price of high-grade pine timber against that of framing grades of Douglas fir.

(f) ECONOMIC DIFFERENCES - INCLUDING UTILIZATION PLANTS

The effects of including the sawmills with the forest budgets of the two species are similar (in proportion to the volume of sawlogs included). This is the natural result of the methods used in calculating mill costs and profits, together with the ages - 35 to 37 years - when the bulk of the sawmill capital is required for both species if PR I is used. The degree of further processing possible is higher for finishing than for framing timber, but this has been excluded in the comparison.

The effect of adding a share of the postulated pulp and paper mill capital and profit margins is to sharply increase the profitability of radiata pine, measured by L.E.V. and I.R.R. Although land to afforest is one of the critical needs for an exotic-based pulp and paper industry, the L.E.V. criterion does not reflect the large capital inputs required by taking this price point. The differences in I.R.R. still favour radiata pine, even at a low rate of assumed pulp profit.

The profitability of radiata pine grown solely for pulpwood, and not based on combined high-grade timber and pulpwood production, is lower; its comparative profitability with Douglas fir depends on the profit margins assumed. From a national viewpoint, radiata pine even in PR I gives greater returns since it is more suitable for the capital-intensive processing of the pulp and paper industry, whereas Douglas fir is grown primarily for a particular - and not the highest - category of timber. The superiority of radiata pine in PR II over-rides <u>any</u> qualification to the Douglas fir results. The choice of species will depend on relative capital and market availability, and whether foresters are prepared to both stop attempting to maximize yields, and to execute simple prescriptions accurately.

(g) RELATIVE RISKS

The risks incurred by the two species differ. Radiata pine has been more affected by pathogens; to some extent due to its ability to exist at all. Epidemics of *Phomopsis* and *Diplodia* in the 1930's, which followed frost damage when radiata pine was planted on exposed sites, typify this ability. Many of the untended areas of malformed trees which apparently affront overseas foresters (Sherry,1958) are a legacy of this ability. Douglas fir, when planted on such sites fails completely (Fenton, 1967a) (12,000 acres of the 18,000 planted in southern Kaingaroa from 1930 to 1933 failed - Kirkland, 1968) and so 'avoids' infection. The 'full scale and wide spread epidemic' of Sirex reduced the numerical stocking of 'some 600,000 acres of radiata pine by about thirty per cent' (Rawlings , 1955). No full quantitative assessment of its effects were made, and on Permanent Sample Plots for example its effects were 'sudden and very local' (Beekhuis, 1966). Currently Sirex is quiescent and almost a rare insect - it is now difficult to collect enough in which to rear parasites in an insectary (N.Z. For. Serv., F.R.I., 1964). Douglas fir is unaffected by Sirex and its associated fungus. The latest pathological trouble is Dothistroma whose advent is so recent that its impact has not yet been assessed, but full control costs have been allowed in the 1968 budgets of PR I and PR II. The difficulty in making any sensible estimate of the impact of pathogens and insects is exemplified by the omission of any mention of Dothistroma from the exhaustive list of diseases of radiata pine (Rawlings in Scott, 1960) and even more recently '...foliar diseases cause very little economic loss' (Newhook, 1964). Similarly Fomes annosus is 'not uncommon in New Zealand and ideal opportunities existed for over 30 years for it to attack plantations' (Newhook, op. cit.) yet it is quite unimportant, contrasting with Northern Hemisphere experience. Whether the point of view of Peace (1962) that 'any effort to impose broad generalisations on a subject so imperfectly understood as forest pathology is to court disaster', or the assertions of De Gryse (1955) are followed should depend on quantified historical evidence. The losses incurred by radiata pine should be assessed against its growth rate, particularly of the top 100 s.p.a. (1), but such data are rare. The risk incurred by plantations of radiata pine, even expressed in terms of past losses, is difficult to assess as 'one feature which deserves special mention is that the outbreaks are seldom repeated' (Rawlings, 1955) and 'few tree diseases have advanced at the rate or in the way that was expected of them from evidence provided by their initial attack' (Peace, 1962). Douglas fir has had a

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(1) By definition the 100 trees of largest diameter per acre.

negligible history of pathological troubles, but the extent to which this is due to its overall correct siting, its capacity to fail completely, and its limited extent (less than a tenth of the area of radiata pine), or its fundamentally better adaption to its environment is impossible to tell.

Windthrow on any catastrophic scale has been restricted to stands of radiata pine, particularly in Canterbury. The damage is due to the shallow soils, rather than the susceptibility of the species. Douglas fir does not thrive at Balmoral or Eyrewell; it is generally windfirm - on shallow soils 'surprisingly' so - possibly due to extensive root grafting (Spurr, 1961) and in any case is planted on the least windy sites (Spurr, op. cit.).

The silvicultural risks in growing Douglas fir are incurred in its early years. An example of unforeseen risk due to poor management was the loss of nursery stock due to unscreened use of Simazine weed killer in nurseries in 1960-61; this is reflected in and partially accounts for the decrease in the proportion of Douglas fir planted, despite general enthusiasm (Hinds and Reid, 1957; Spurr, 1961) for the species immediately beforehand. Fortunately radiata pine proved resistant to all but the heaviest doses - an unforeseen ability. The consistent risk is that incurred by the slow initial growth after planting; weed growth on the fertile sites often reserved for Douglas fir is heavy and release-cutting should not be neglected. Gorse is particularly troublesome. The fast initial growth rate of radiata pine reduces this problem. Once successfully established greater managerial risks due to poorly timed or executed tending is incurred by radiata pine. Douglas fir reportedly stops ground fires (Hinds and Reid, 1957) but little evidence is available to support this.

The last complex of risks are those of marketing. Finished timbers may be largely supplanted by panel products, in the United Kingdom, for example, particle board has had 'a tremendous increase in use for flooring' (Anon, 1966d) and in Europe it is one of the most rapidly expanding of all industries. In the U.S.A., the rate of expansion of plywood production has been sustained - increasing 2½ times from 1954 to 1964 (U.S. For. Serv., 1965). Competition from substitutes is likely to intensify, the aluminium industry anticipates its major market will be in the building and construction industries. Conversely, a steady supply of even ten per cent clearwood, may find markets in 2000. Properly designed panel products may equally reduce the proportion of framing timber required. At present, radiata pine is more versatile as timber and as a source of pulp material, than Douglas fir; if the forecasts for timber consumption (Grainger, 1961) are correct then radiata pine will maintain the advantage of versatility. The big market growth-potential, if North American precedents are followed, is in plywood. Radiata pine is easy to peel and is a major plywood species, but the qualities of exotic Douglas fir as a peeling timber are unknown, the disequalities of texture may cause gluing problems which would reduce its use.

(h) SUGGESTED MANAGEMENT POLICY

The two species can complement each other as to site. Nationally, and if land policy were dominated by economic considerations, radiata pine would usually have a freight advantage over Douglas fir since it can be grown in areas subject to salt winds and thus planted closer to the ports and the major domestic markets. But '...especially...in...New Zealand the ultimate decision for major development projects will always be political in nature' (Ward, 1964b), and such an advantage remains theoretical. Douglas fir can tolerate, and is even technically suited by a policy of neglect (after successful establishment) and its site requirements are for absence of exposure, and for good air and soil drainage. Hence it is suited both managerially and silviculturally to the hill sites where thinning on present costs and returns (Fenton, 1967a; Tustin, 1968) is too expensive. The highest site qualities, where the growth rates of the dominants of Douglas fir are in any case too high for good quality framing, should be devoted to the intensive tending of radiata pine. The prescribed pruning schedule in PR II if followed and combined with thinning-to-waste, should accommodate the malformation incurred by the species since only the 80 final crop trees, which would produce but three sawlogs each, have to be straight enough to justify pruning. Successful tending of radiata pine depends on early, successive pruning and thinning and malformation above the two lowest logs, while undesirable, is not a vital factor. The possibility of greater biological risks to radiata pine has to be balanced against the problematically more restricted markets for Douglas fir. The further the extension into the future, the greater the uncertainty, and the advantage of radiata pine, exploited in PR II regime is a reduction in rotation which also succeeds in producing clear timber quickly. The effects of second-log pruning, linked with a production thinning, in PR I is to extend rotations to 36 years, and even then only a 15 in. s.e.d. second-log is produced. The same sized log, with a smaller knotty core, would be produced as a butt-log by age 20, or less, by a suitable thinning regime. Douglas fir could not match this early performance (even if the resultant timber was acceptable); the rapid growth of radiata pine is exploited in regime PR II.

The economic position is clear - at 1962 domestic prices, Douglas fir has a modest advantage over radiata pine, as the latter is grown at present (viz.as in PR I), and if Douglas fir rotations are reduced. This advantage is lost when exports are included. Future price movements are likely to be to the advantage of radiata pine. The latter can also be subject to a greater degree of processing by the pulp and paper industry with enhanced profits, if the capital cost is not limiting. The silvicultural and managerial simplicity of Douglas fir with the risk-spreading allowed by its inclusion, could argue for its inclusion as a complementary species in afforestation, but the potential profitability of radiata pine - still untapped but indicated in PR II results - is overwhelmingly better.

TABLE 11 - 1 SILVICULTURAL CHARACTERISTICS OF DOUGLAS FIR AND RADIATA PINE

Characteristic	Douglas fir	Radiata pine	Effect
Stocking and mortality	Low mortality up to at least age 50	Variable mortality, locally exaggerated by Sirex epidemics (1) Currently more susceptible to disease.	Management more comple for pine.
Branching - frequency	Generally multinodal	Variable; a number of uninodal growth periods on most trees	Clear-cutti grades avai able from pines only. Diffuse defects in fir.
Branching - longevity	More shade tolerant, and harder to kill	Hard to maintain green crown (2)	Knotty finishing timber hard to grow.
Branching - persistence	Dead branches highly persistent	Dead branches highly persistent	Clear finishing timber necessitate pruning.
Branching - diameter	Wide range	Wide range	Small dead branch defects present ear in both spp
Stem form	Low incidence of malforms	Much higher incidence of malforms	First thinn ing of pine usually to waste.

(1) Beekhuis, 1966

(2) Beekhuis, 1965

TABLE 11 - 2 MANAGEMENT DIFFERENCES BETWEEN DOUGLAS FIR AND RADIATA PINE

Operation	Remarks
Pruning	
Occlusion	Without trouble for both species if pruning of good standard.
Frequency	Relatively high d.b.h./height ratio of pine necessitates smaller pruning steps to achieve the same core diameters.
Actually done	Proportionately greater areas of fir treated.
Thinning	
Actually done	Proportionately greater areas of fir treated.
Response	Good for both species, even if delayed; fir response exceptionally good.
Clearfelling	
Actually done	Little felling of fir; large areas of untended pine felled annually.

TABLE 11 - 3 AREAS PRUNED ANNUALLY IN STATE FORESTS

Year	Area pruned 0/6 or 0/8 ft	Area pruned To 18 ft	Remarks
1940 and earlier			Totals are not available.
1941	9406		) Height of pruning
1942	4916		) not differentiated.
1943	2265	729	
1944	3887	505	
1945	4673	391	
1946	5340	458	)
1947	6556	932	) Largely of old
1948	6743	1983	) stands of Corsican
1949	6729	2243	) pine in Southland.
1950	7580	1827	)
1951	5021	2120	
1952	6330	3728	
1953	7063	4324	
1954	4728	6171	High pruned areas exceed
1955	3766	6482	low pruned areas from 1954 to 1961 in most year
1956	4936	5974	
1957	8959	7729	
1958	7019	7727	
1959	5604	6341	
1960	6018	10560	
1961	8310	9163	
1962	8325	6535	
1963	9429	4938	
1964	8958	5036	
1965	15585	6454	
1966	16647	6187	
1967	15539	5267	

Sources: Yska (1967); and N.Z. Forest Service Annual Reports.

TABLE 11 - 4 AREAS OF DOUGLAS FIR HIGH-PRUNED IN STATE FORESTS

(Areas in acres)

Year	Total area of Douglas fir pruned to date To 18 ft	To 36 ft	Area pruned that year To 18 ft	To 36 ft	Area clear-felled
1963	19199	12	261	12	51
1964	16979	12	150	0	38
1965	14238	17	449	0	111
1966	13624	17	499	0	81
1967	13591	17	252	0	70(1)
1962 in Kaingaroa	15054(2)				

(1) Provisional

(2) D. H. K. Ross pers. comm.

Source: Annual Reports N.Z. Forest Service for the respective years.

TABLE 11 - 5 COMPARATIVE LABOUR REQUIREMENTS AT FOREST NORMALITY

Category	Douglas fir regime B	Radiata pine PR I		Radiata pine PR II
Supervising Staff	11	12		9
Indirect labour and other staff	26	25		24
Labour for establishment	6	3		3
Labour for pruning and thinning to waste (1)	0	23+	(26)	22
Labour for production thinning	51	23		0
Labour for clearfelling (2)	26	33		34
Totals:	120	119		92

(1) Later studies showed lower labour requirements for pruning than used in the original PR I study. The original total is in brackets.

(2) These figures could be reduced if higher man-hour-production rates were allowed.

TABLE 11 - 6 EXPORT AND DOMESTIC PRICES OF NEW ZEALAND RADIATA PINE

Values are in $ per 100 bd.ft

Grade and size		Price - domestic list			Price - export
		At Mill	Net of discounts	At export port	
		(1)	(2)	(3)	(4)
Dressing	4 & 5 x 1	6.45	5.82	7.01	7.25
	10 x 1	9.00	8.11	9.30	8.00-10
Merchantable	8 x 1	5.10	4.60	5.79	7.00
Construction (equivalent to No. One Framing)	4 x 2	6.45(5)	7.62	8.81	8.50
Box	6 x 1	4.15	3.74	4.93)	5.15
	9 x 1	4.45	4.01	5.20)	

(1) Price list used for Maraetai radiata pine (Fenton and Grainger, 1965); prices before discounts are made.

(2) Domestic sales are usually subject to 7.5 and 2.5 per cent discounts.

(3) The equivalent price of exports is based on domestic prices plus freight of $1.19 from Tokoroa to port.

(4) Export price list, F.A.S.; Radiata pine Division, 1964.

(5) Construction grade is kiln-dried to 15 per cent moisture content for export; the charge is $2.00 per 100 bd.ft.

CHAPTER 12 - THE ROLE OF PRODUCTION ECONOMICS, AND EXOTIC FOREST POLICY

(a) PAST POLICY - ITS ACHIEVEMENTS

As outlined in Chapter 1, the exotic forests largely result from extensive planting during 1925-35. They were originally established '...to provide internally for our annual needs' (Ellis, 1925) (1). Accurate estimates were made of future timber consumption, the forecasts made in 1925 for 1965 being only nine per cent below the actual figure. The expansion of the then 63,000 acres of State plantation accorded with Conservationist philosophy elsewhere (Barnett and Morse, 1963), being justified by both an assumed indispensibility of forest products and by the predicted end of economically accessible indigenous supplies. In 1925 it was predicted that the indigenous cut would be reduced to 30 million bd. ft by 1965, whereas it was 249 million bd.ft. The anticipated date of exhaustion of the economically available supplies of indigenous softwoods was 1965-70 (Ellis, 1925), whereas it is now beyond 2000. Afforestation by private companies has been three times greater than anticipated in 1925 (Entrican, 1960).

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(1) In the "First Quinquennial Review of the Operation of the National Forest Policy"; it proved to be the only one; other policy statements are in Departmental Annual Reports and, since 1923, in Statements to Imperial, Empire or Commonwealth Forestry Conferences.

Exports were mentioned in 1937, '...As stressed in previous annual reports, the long-term policy...(is) ...to meet only the local requirements...but with the limiting factor of(Consolidated Fund loan money) interest removed, the growing of timber for the Australian market becomes...feasible', (N.Z. For. Serv., 1937). It was later maintained (Entrican, 1960) that the extensive private company plantings caused Ellis to elaborate 'plans to provide for the establishment of a newsprint and kraft pulping industry to compete on the overseas market at world parity prices'. Although the statement '...New Zealand has always planned for a continuing export surplus of 50 million cu.ft' (Williams, 1964), appears exaggerated, post-war (1945) policy has aimed at exports (Anon, 1952; 1957; 1962b).

Overall, the original policy of the 1920's has been successful, since only 20 per cent of the round-wood volume now cut is of indigenous species, and since 1963, the value of forest product exports has exceeded that of imports, (Fenton, 1968b).

A particularly beneficial effect of past afforestation has been its concentration in time and place, which has allowed the establishment of two large integrated mills. Whether this concentration was due to planning, to chance or a combination of the two is now largely of historical interest, what is significant is how strongly this benefit has been discounted due to forest management difficulties '...the lesson should be a salutary one. Never again, it is hoped, will there be any necessity to compress the establishment of an exotic species into ten years instead of spreading it over an entire rotation', (Entrican, 1960). Planting since 1935 has been widely dispersed over time, in area and amongst different species (Tables 1-1 to 1-4). The result is that development of further large-scale integrated utilization plants outside the Bay of Plenty is currently impracticable, as many forests - although too large for local supply - are inadequate for large-scale newsprint or sulphate-pulp production. The desirable minimum size plant should be of about 500 tons (of pulp products) per day capacity, for which the minimum wood requirement would be 15 million cu.ft annually, (Williams, 1965). Currently, State planting is spread over 90 different forests and is no more concentrated than in 1960. For example, Nelson has the greatest potential for a new pulp mill (Williams, op. cit.) but the share of new planting there has increased from

16 per cent to only 17 per cent of afforestation since 1960. The beneficial effects of past concentration are not being repeated. It is debatable if it is indeed desirable to build up a forest by 'normal' steps. The investment necessary for a 50,000 acre forest with a net M.A.I. of 300 cu.ft required for the minimum 15 million cu.ft requirement will be greatly increased if a 'normal' management structure is planned. By increasing initial planting, by utilizing younger stands and by proper planning, returns can be obtained earlier. Conversion to eventual normality can be by 'thinning' of part of the initial planting (when the operation is in large-size trees) as in the PR II regime.

(b) PAST POLICY - ITS LESSONS

Naturally, there have been shortcomings. In particular timber exports up to 1967 have been disappointing. Typical expectations were '...exotic forests must be systematically developed to yield...up to 150 million bd.ft for export within about 15 years (viz. by 1964)' (N.Z. For. Serv., 1949); '...60 million bd.ft will be exported annually (from the Tasman Pulp and Paper Co. Mill)' (N.Z. For. Serv., 1952), '...the greatest expansion of the export trade will come with the establishment of further large sawmills in the exotic forests' (Anon, 1952). In 1954, when integrated mills started production, exports rose to 13 per cent of the total radiata pine cut, but have since declined to half this proportion; exports comprise a steady ten per cent of Factory grade, an increasing proportion of Box grade, and a short and passing contribution from Construction (Framing) grade, (Fenton, 1968b). Although low grades were anticipated, high volumes of exports were still hoped for, as mill integration was to reduce the proportion of low grade timber. By 1955, doubts had appeared '...New Zealand has barely touched the market for higher grade ... (and) ...has done little to get footholds in these markets...' (N.Z. For. Serv., 1955). In 1960 the absence of tending was being blamed for the '...insignificant proportion of clear and defect-rare grades' produced, whereby only 50 million bd.ft of timber were exported (Entrican, 1960). Realization came '...When the Kawerau (Tasman) mill started a decade ago, the N.Z.F.S. predicted that we would sell 150 million bd.ft of sawn timber annually to Australia...yet despite intensive promotion there has been no significant increase in the last decade...' (Larsen, 1965). And '...The timber side has been a relatively weak point for Tasman for most of its history and one can wonder if the directors would again invest the large amounts...now tied up in timber production... if they had to do it again...' (Sturman, 1966). The case argued for integration (Entrican, 1957) was based on micro-wood technology, and although indisputable, largely ignored the branches; the pattern of branch-defects within the tree is such that the only practical method of obtaining finishing grade boards is by recutting and reassembly. The growing incidence of defects with increasing age of the stands (Fenton, 1967b) will continue to depress production of finishing grades and, apart from Factory Grade, integration cannot reduce these by log sorting.

Expectation that 'older' stands would produce better grades is only partly true. The anticipation that '...the long rotations of 50 years or more...will then yield a significant proportion not only of clear and defect-rare grades but of heartwood of good durability and excellent dimensional stability' (Entrican, 1960) is wrong with regard to board grades while the characteristic of durability is now almost unimportant with the advent of a wide-spread preservation industry. The only significant yields of tight-finishing grades of boards that can be produced from radiata pine are from young stands about 25 years old; the alternative source of finishing quality boards is of Clears from pruned stands. The lack of comprehension of the silvicultural characteristics of plantation-grown timber led to the assumptions - now proven to be optimistic - of an export trade of 100 to 150 million bd. ft annually.

The timber potential is quite different for framing - or construction - timber; older stands will produce an increasing proportion of better grades (Fenton, 1967b), but industry has not produced the kiln-dried product required for export (Fenton, 1968b). Framing timber is not generally required in a seasoned condition on the less-demanding New Zealand market, and the timber industry has been content with domestic, rather than export sales.

The past record of pruning in State forests is exemplified by the rarity of stands represented by Hull's trees, which were some of the very few available on which to even check on the results of pruning. Future clearwood potential is calculated in Appendix 5 and shows that, if a 22 per cent thinning regime is applied and the final 60 s.p.a. are of 25.0 in. d.b.h. and 130 ft top height (Beekhuis, 1966), then the yield of clearwood from two pruned logs per tree is about 8,000 bd. ft per acre. There will also be about 13,300 bd.ft per acre of Factory and Dressing grades. Hence a 5,000 acre annual pruning programme from 1965 could result in about 40 million bd. ft being available from about 1986 onwards if pruning is concentrated on to the highest quality sites, and priority is given to radiata pine. The belated pruning of the 1950's will increase the overall yield of Factory grade - on comparably thinned sites - by 3250 bd. ft per acre above that of unpruned stands from 1986 onwards. The yields from other pine species will be much less, as final crop diameters will be considerably lower.

The fundamental problem, as discussed in Chapter 11, has been the inability to appreciate the interactions between age, tree characteristics and timber quality in plantations.

(c) THE PLACE OF ECONOMICS IN LOCAL MANAGEMENT (1)

Present management has evolved with limited economic justification, and as profitability has not been a primary aim, costs have often been of secondary importance.

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(1) 'Local' signifying at the forest or district level.

While lack of concern with costs directly reflects on efficiency, it also has a more profound effect as it distorts attempts to forecast what profits could be made. Historical costs have to be used which are derived from management where economic efficiency is not paramount. This is exemplified by the man-hour-production data used in logging in Chapters 8 and 9, apparently it is acceptable to allow a clear-felling gang equipped with $100,000 of capital equipment, to log less than one tree per man-hour and to restrict production to a net 35 hours per week.

The necessity for accurate costs and physical data are self-evident, '...it can be dangerously misleading if rather flimsy physical data are masked by a sophisticated mathematical technique [of economic analysis]', (Stonyer and Donovan, 1968). Economic analysis at the forest, or at higher levels depends fundamentally on accurate data, and this accuracy has to begin at the forest level. Some management record inaccuracies have been given in Chapter 10. Once accurate costs are demanded, an economic incentive is provided and overall efficiency can improve. Accurate costs permit comparison both with past results and with results elsewhere.

At a local level, comparisons in profitability of species, or of silvicultural practices, must fully allow for any differences in the treatment required. The calculation of pruning profitability discussed in Chapter 3 and Appendix 5, for example, showed the original evaluations (Brown, 1965) mistakenly assumed the pruned and unpruned trees should be grown on the same rotation. The Faustmann approach is safe to use when the alternatives have appropriate lengths of investment-period allowed.

The great problem in local management is the substitution of economic for technical prescriptions. There is no particular silvicultural merit, or demerit, in the present Conservancy and private company regimes (Bunn, 1963), with their requirements of 36-40 year rotations in radiata pine, and of 80 year rotations in Douglas fir, but economic justification for such aims has been entirely lacking.

(d) THE ROLE OF ECONOMICS IN NATIONAL FOREST PLANNING

Prior to 1959 there had been little attempt to calculate results of 'large-scale rural development schemes in New Zealand...[in economic terms]' (Stonyer and Donovan, 1968) and forestry was no exception. This was not unusual - in Canada, for example 'What is remarkable is that none of this kind of analysis is ever carried out ', (Scott, 1963). There has been a rapid change in other industries in New Zealand and 'it is very encouraging to see a fairly sudden acceptance of the necessity for [cost-benefit type] analyses' (Stonyer and Donovan, 1968). Use of such analyses must be increased in forestry, particularly as a guide to decision making. Planning should be centralized to avoid local bias and to comply with an overall national aim, as '...insistence on cost-benefit analysis can help in the rejection of inferior projects, which are nevertheless promoted for empire-building or pork-barrel reasons' (Prest and Turvey, 1965). Piece-meal schemes should be placed in a national perspective in order to make the best use of scarce resources of capital, land and labour.

The problem of criteria to use, discussed in Chapter 5, is perhaps best met by presentation of both some form of the Present Net Worth criterion, together with a statement of the Internal Rate of Return earned. For any project, these should be accompanied by statements of the land (area and quality), and labour (number and skills) necessary, together with the allocation of capital, land and labour through time.

The budget approach used in the original Maraetai study (Ward et al, 1966) and here both accommodates these requirements and provides a firm empirical base on which to build improvements, as better data become available. The range of physical and financial data required is extensive and changes in costs and prices with the passage of time, have to be allowed for by recalculation. (Changes in timber grade outturns; in timber prices and in milling costs have been made in Chapter 9 to the original (1962) PR I results, for example; and modifications of pruning, planting and other costs were made in the sensitivity analyses of Chapter 9).

Nationally, the extra cost of intermediate yields can be calculated if extra volumes are required. Additional volumes are undoubtedly available in densely-stocked unthinned stands.

One of the greatest difficulties in forest economics in New Zealand is incurred in the extension of analysis to include utilization costs. The analyses presented in Chapters 8 and 9 are at least sufficiently well-based to allow discussion of the costs presented in logging and sawmilling (though all the costs given need to be known more accurately), but it must be granted that treatment of pulp and paper manufacturing cost and profit is not so comprehensively based. This is stressed here, rather than in Chapter 10, as it will increasingly embarrass analysis. The freedom of agricultural analysts who 'are in no sense sponsored by partisan interests, there is freedom for reports to be as strongly for or against proposals as an objective analysis demands', (Stonyer and Donovan, 1968) is not, unfortunately, available in New Zealand forestry.

Few financial data on the pulp and paper industry are available, presumably as the few companies concerned are either large buyers of state-grown logs or are monopolies protected against imports. This dilemma will have to be solved, particularly since the increased degree of processing is often invoked as further justification for forestry. If the export values of newsprint remain at 87 to 100 cents per cu.ft of round produce equivalent (Fenton, 1968b) then the current stumpage of 2.5 cents per cu.ft represents less than five per cent of the cost of newsprint. Whether this is an appropriate stumpage in proportion to the forest and utilization capital employed (and the New Zealand Government owns 29 per cent of the newsprint company's ordinary shares) depends on unavailable data.

In discussing the application of public investment analysis 'the lesson to be learned...is that the analysis of public investment projects should be made the responsibility of an agency which is independent of any construction[viz. operating] authority' (Musgrave, 1968). The New Zealand Forest Service is too closely connected with the operation and management of production forestry to be thought to be independent of or by the pulp and paper companies; the appropriate agency should perhaps be an independent economics group, possibly one attached to a University.

(e) FUTURE FOREST MANAGEMENT

The projection and analysis made for radiata pine in Chapter 3 and Appendix 6 (regime PR II) shows that a rotation of 25/26 years to produce 80 final s.p.a. of 23 in. mean d.b.h. is feasible on Site Indices of 95 ft (Lewis, 1954). In the past, the desire to obtain an (assumed) greater physical yield per acre has, presumably, led to prescriptions including extraction thinning, which have had the effect of lengthening the rotation. Retaining sufficient stems to ensure an (again assumed) merchantable volume of thinnings has caused loss of increment on the final-crop trees.

The previous regimes were, in fact, the descendants of classical doctrines of maximum yield discussed in Chapter 5; they represented forest rent taken to the simplest case of reduction of extraction thinnings to a minimum of two or one per rotation, (Ure, 1949; Fenton and Familton, 1961; Bunn, 1963). Their probable genealogy apart, these regimes have nothing to recommend them in view of the record of production thinning to date (Fenton and Brown, 1963; Fenton, Mackintosh and Hosking, 1965; Tustin, 1968). But nowhere in New Zealand were attempts deliberately made to grow (i) untended crops or (ii) crops which accepted present limitations on extraction thinnings until the hypothetical Maraetai analysis (Fenton and Grainger, 1965) prescribed (i) on hill country. Another hypothetical schedule was given for (ii) (Bunn, Familton and Fenton in Bunn, 1963 - p.191), a version of which was prescribed for Wellington Conservancy by A. K. Familton. Perhaps the case should be justified for prescribing production thinning rather than the reverse. Thinning operations (for major produce - saw and pulp logs) in young radiata pine have failed over 18 years to produce intermediate returns; stands have been kept at high density at the sacrifice of growth-potential of the final-crop pruned trees; from 18 to 40 per cent of the final-crop trees have been damaged (1), and crop tree numbers reduced by from 10 to 35 per cent; the regimes are demonstrably inferior in economic terms (cf. PR I with PR II), and finally, the net mean annual increments have not been increased. (The fact that pruning has also been misdirected need not enter this argument). When extraction thinnings which are executed to within, say, five per cent of a prescribed intensity and which can be made with intermediate net financial yields, then PR I type regimes could be considered and New Zealand forestry could follow the general forestry practice in retaining management with intermediate yields.

A particularly strong merit of the PR II type regime is that the restraint of topography, hitherto dominant in management schedules, is greatly reduced. While the record of production thinning of radiata pine on country workable by tractors is bad enough, no attempt has been made to extract major produce from steep sites. Extraction costs of intermediate yields of (35 year or older) Douglas fir on steep country are double those on easier, flatter sites (Fenton, 1967a). As extensive plantations are already planted on steep

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(1) The significance of this damage is unknown at present.

sites, PR II type regimes offer an immediate solution to the problem of their management. (Clearfelling costs on steep sites are usually within 25 per cent of clearfelling costs on easier topography).

The data necessary for **optimizing** are discussed in Chapter 10, the regime PR II is not necessarily an optimum solution (which in any case is determined by the subjective choice of an interest rate). Figure 12 represents an analysis of the costs of regime PR II expressed in terms of Land Expectation Value; sawmilling, extraction, indirect and social costs comprise over 75 per cent of all discounted costs, at an interest rate of six per cent, and dominate all other costs. The graduate research staff allocated to these fields (who are also responsible for tending representing a further **ten** per cent of the costs discounted at six per cent interest rate) since 1967 by the New Zealand Forest Service, totals four of a total of 68.

Naturally the work of other groups, particularly in tree improvement, soils and mensuration, impinges on these costs, but the direct research input, it is contended, is not high. Clearly it will be some considerable time before sufficient data are obtained to enable more sophisticated solutions to be found. (No data are available on research allocation outside the New Zealand Forest Service). Possibly the allocation of research effort exemplifies, as do the schedules typified by the PR I regime, management preoccupation with aims other than increasing profitability.

The original approach of Craib (1935; 1939; 1947) in South Africa, has been termed 'rational and positive' (Lewis, 1964), and is critically examined elsewhere (Fenton, Sutton and Irvine, 1963). The relatively high (125 s.p.a. at 117 ft top height on S.Q. I) final stocking was criticised by Lewis

> '...it is difficult to imagine a further thinning between ages 25(when 110 - 120 s.p.a. remain) and 40 on S.Q. II ... sites failing to improve on present...economics in view of the extra intermediate return [there], the arrest of declining ring-width, the consequent acceleration in value growth, and the ultimately larger final crop tree which the reduction in final stocking would allow' (Lewis, op. cit.).

The initial rationalization of Craib has been taken further in the PR II regime, as considerably more utilization studies are available in New Zealand than were available originally to Craib. These studies showed (Tables 3-6 to 3-9) that concentration not only on the final crop trees, but also on specific logs and the comprehension of the effects of their associated characteristics in relation to grade, can yield greatly improved results. Further, overall yields are not decreased, and the yields are available a decade earlier, with all the consequent benefit to national planning that follows. (These benefits are the bringing-forward in time of large, exportable surpluses). The saving in labour and capital is considerable, and as M.A.I. are unaffected, no extra land is required. Alternatively, a more vigorous approach to the problem of executing efficient production thinning may yield good results - but the effect of any loss of increment on the final crop trees must be allowed in profitability calculations.

Whether the type of approach exemplified by the PR II regime in Chapters 3 and 9, or even 'short' 50-year rotations for Douglas fir analysed in Chapters 2 and 8 will be adopted is conjectural. As discussed in Chapter 11 the approach to pruning has often been indefensible, with initially a lack of even elementary analysis and since the release of grade study results since 1960, an apparent inability at times to recognise research results. The production thinning record in young radiata pine (for major produce) is equally lamentable. Possibly the most beneficial result of shortened rotations would be the allotment of responsibility for results, as the rotation is within the span of a career. However, until economic responsibility and a ceaseless analysis of all changes in factors of production are demonstrably an integral part of forest management, there is little reason, based on past records, to anticipate great improvement. Plantation forestry in New Zealand could yield good returns if the primary aims of concentration, of short rotations and of directed silviculture are applied to the remarkable growth potential of radiata pine.

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NEW ZEALAND'S EXPORT TRADE IN FOREST PRODUCTS WITH AUSTRALIA

R. T. FENTON

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NEW ZEALAND'S EXPORT TRADE IN FOREST PRODUCTS WITH AUSTRALIA

R. T. FENTON*

SYNOPSIS

New Zealand exports of forest produce to Australia were traditionally of high quality indigenous softwoods; the reverse import trade in hardwoods and pulp and paper products became worth twice the value of exports by about 1950. Exotic softwoods began to predominate in exports from the late 1940s and were exceeded in value by kraft pulp and newsprint in the 1950s. Timber exports are largely low grade and during the past 10 years, as a proportion of total New Zealand and Australian sawn exotic softwood production, they have diminished by half.

The Australia-New Zealand Free Trade Agreement does little to liberalize this trade apart from including kraft and fine papers. Australian plans for at least self-sufficiency in forest products are based on a high per capita *sawnwood consumption and make future markets for New Zealand produce there uncertain. If New Zealand exports are to improve over the next three decades, the Agreement should be extended to include timber processing, as the supply potential is mainly of framing and clear-cutting grades.*

INTRODUCTION

Foreign trade is important to both Australia and New Zealand, although the New Zealand *per capita* trade (total imports and exports) of $NZ760 per annum is almost twice as much as Australia's $394 (Oversea Trade, 1964–65; N.Z. Dept Census and Stats. 1965). New Zealand has no resources comparable with those that have led to the establishment of the Australian heavy iron and steel industry, to the long established mining of non-ferrous metals, to the more recently discovered mineral resources, and to the new oil and gas fields. Both countries still depend on primary agricultural products for the largest part of their export income, but the Australian export base is changing rapidly: exports of ores, metals and metal-manufactures, and of chemicals, have all doubled in the last four years (Oversea Trade, 1964–65) and now comprise 22% of exports by value. In addition, New Zealand's agriculture is narrowly based on sheep and cattle farming and has no counterpart to Australian dried and tropical fruits, sugar or wheat industries. New Zealand's pastoral exports are in competition with Australia's.

Despite similar origins, a common language and a comparative geographical proximity, there has been a record of acrimony and

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grievances in their trading relations since at least the 1900s: "National policies have led to mutual criticism in regard to dairy produce; New Zealand has continually objected in the strongest terms to the manner in which Australia has subsidised exports of this commodity to world markets since 1926, whilst . . . New Zealand protection of those industries competitive with Australian secondary industries did not create harmony in trading relations between the two countries" (Bentick, 1962).

These relations were also influenced by both countries' very important trade with the United Kingdom which, although now of less importance than in the past (Japan now (1966–67) rivals the U.K. in Australian trade), is still the premier trading partner of New Zealand. This market was always, and still is, of greater importance to New Zealand which extended considerable tariff protection to the nation which was her best customer. The United Kingdom still takes 45 to 50% of New Zealand exports, but now only about 18 to 20% of Australia's.

Despite their parallel history, mutual Australian and New Zealand trade was not extensive; their competition in external trade and conflicting domestic policies did not lead to the likelihood of any great improvement in general trade between them, although New Zealand bought increasing quantities of manufactured goods from Australia, with whom she has a continually increasing trade deficit. New Zealand is the largest single market for Australian exports of iron and steel (excluding scrap), cars and parts, and petroleum products, and took 38%, 44% and 45%, respectively, of the total value of these Australian exports over the five years up to 1964; they cost New Zealand an average of over $NZ40 million annually over this period.

Recent events in Europe, with the formation of the European Economic Community and the attempts at entry by the United Kingdom, provided an example to override past poor trading relations between Australia and New Zealand, and also a stimulus to diversify exports. The result has been the Free Trade Agreement — F.T.A. — (Commonw. of Aust., 1965). Outside this agreement, the search for markets continues with intensifying mutual competition in such prospective markets as Japan, North America and South-East Asia. In both countries domestic policies are strongly influenced by the principle of autarchy — secondary industries producing goods common to both countries have developed under the protection of tariff barriers, and absorb a relatively high proportion of the labour force. This development occurred much later in New Zealand than in Australia. A consistent policy of both countries has been stimulation of domestic industry (by import restriction or by tariffs) to reduce reliance on overseas trade. As forest products have generally represented a net import, national self-sufficiency has been an implicit part of forest policy. The most marked intention of the recent Free Trade Agreement could be to ultimately amend this general policy as complementary forest industries are developed.

The forest products trade is of particular importance to New Zealand as it has comprised over half (from 50 up to 63%) of the total value of New Zealand exports to Australia in the last decade. The total imbalance in trans-Tasman trade is now (1966) $NZ100 million annually.

PAST FOREST PRODUCTS TRADE

In contrast to the general trading situation, the traditional trade in forest products between Australia and New Zealand has been complementary. Strong and durable Australian hardwood species were available for export. The absence of creosote production (then the only major timber preservative) in New Zealand, and of sufficient supplies of durable indigenous species resulted in her following the Australian precedent in using hardwood timbers for heavy engineering and constructional uses, as well as for poles and railway-sleepers. Such timbers were imported from Australia. The reverse trade has been of light and medium-density, defect-rare, indigenous softwoods which in turn were relatively scarce in Australia. This mutual trade was reduced during the 1939–45 war. The development of a pulp and paper industry in Australia led to small scale exports from about 1950, but timber and roundwood remain the major Australian forest products exported to New Zealand. The forest products trade was of modest scale — for example, values comprised about 4% of total Australian, and 4 to 12% of total New Zealand exports, to the other country in 1950. Details are available (Yska, 1967; Wilson, 1964), and the financial balance was in Australia's favour; for example, from 1946 to 1953 by a ratio of two to one.

The original timber trade has been modified partly by the decreasing availability of Australian supplies and more particularly by changes within New Zealand. The prohibition of exports of indigenous softwoods ended one side of the trade (by 1952), while the development of a preservation industry (based largely on pentachlorophenol and water-soluble multi-salts rather than creosote) eventually provided a degree of substitution for durable hardwoods. Imports of hardwoods still continued but on a reduced scale — in 1955 the reappearance of jarrah prompted the comment: "West Australian hardwoods are popular in New Zealand and it is hoped that this newly revived trade will continue" (N.Z. For. Serv., 1955). Both countries maintained a fluctuating system of import controls, which Australia lifted in 1960; they remained in New Zealand until the F.T.A. came into force. The two countries each remain the major markets for the other's sawn timber, although Australian export markets are more diversified. Over the five years from mid-year 1959 to mid-year 1964, for example, New Zealand took 48% of the value of total timber exports from Australia. In the reverse direction, Australia took 82% of New Zealand sawn timber (Oversea Trade 1963–64; Yska, 1967).

The export of exotic pine timber to Australia began during the 1939–45 war; the market was largely for box-shooks. Pine exports increased and in 1947 volumes exceeded the exports of indigenous softwoods. A more important change came in the early 1950s when two large integrated mills were built in New Zealand; the effect of exports of pine timber, newsprint and sulphate pulp was to reverse the trans-Tasman balance of forest products trade to favour New Zealand. Eventually, in 1963, New Zealand achieved an international surplus of trade in forest produce, despite increased imports. Australia remains a heavy net importer, though the value of her total imports is often exaggerated at $A.200 million. The annual value of imports over the 1960s has averaged three-quarters

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THE ROLE OF DOUGLAS FIR IN AUSTRALASIAN FORESTRY

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THE ROLE OF DOUGLAS FIR IN AUSTRALASIAN FORESTRY

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SYNOPSIS

Douglas fir timber sold in New Zealand comprises about 5% of the exotic cut, produced mostly from three modern mills. It is acceptable in house-framing without preservative treatment, is sold ungraded, and has never been subject to price control. It originated in well-stocked stands which usually remained unthinned for forty years, with consequent suppression of the lower crown, reduction in knot size and branch life, and reduction in stem diameter growth rates; thus it is well suited to its major end use as framing. It adds further to the relatively abundant supplies of framing timber available, but is less versatile than radiata pine.

A third of the thinned volume (the smallest logs) has been used as rounds, with a consequent increase in overall profitability. The apparently greater value of Douglas fir, compared with radiata pine, is partly due to circumstances and partly to its particular merits.

Douglas fir from North America is the major species imported into Australia, and the effect of its absence from Australian afforestation is examined in relation to North American and New Zealand supplies. The North American old-growth resource still dominates the trade but export sources are likely to change to young-growth stands, and to hemlock. While there is a tariff advantage for New Zealand over North American supplies, the freight advantage is negligible.

The relative cost of production of the Australasian and the North American material is not known. The relative economics of Douglas fir and radiata pine in New Zealand have still to be assessed.

CURRENT TRADE IN DOUGLAS FIR

Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) is one of the great commercial timbers of the world and, because its qualities coincide with the market requirements and it is readily available from the north-east coast of the Pacific, it is of particular importance in the forest products trade between Australasia and North America. Details of Douglas fir imports are given in Tables 1 to 4. New Zealand domestic production is included in Table 5. Douglas fir comprised half the volume and value of Australian timber imports over the past two decades. Its position as the most important species of timber imported into New Zealand has altered recently and in 1965 imports of both redwood (*Sequoia sempervirens* (D. Don) Endl.) and western red cedar (*Thuja plicata* D. Don) equalled it in volume. Internationally, Canada is the premier exporter of Douglas fir and has tariff advantages in Australasia; but the bulk of the New Zealand and about half of the Australian imports come from the United States. There is a small export trade from New Zealand.

Most of the pre-1939 Australian imports were in the form of logs, but are now in large baulks for subsequent resawing (Commonwealth of Australia, 1960, 1963). Importation in this form allows timber merchants to hold stock which can be utilized in diverse ways; it also permits a large amount of re-manufacture and incurs a lower tariff (Table 6). These baulks are reportedly "bought at premium prices, of course, since they are cut from what would otherwise be peeler logs. Operations not integrated with peelers find this business a valuable and welcome outlet for their best fir logs and timber" (Anon., 1959). Comparative prices of the size classes imported are not available from Canada. However, the U.S.A. prices (Table 2) show a much lower c.d.v.* cost for the small sizes. Presumably the anomaly is due to differences in grade. The overall prices of the imported timber, which are on a c.d.v. at port or f.o.b. basis, compare reasonably well with North American wholesale prices (Table 7), as the latter exclude freight costs.

Consideration of direct substitution of these imports by production from exotic forests arises from the national forest policies of both Australia and New Zealand, and from the dominant position of Douglas fir in the timber trade. Only limited areas of three Australian states have climates suitable for Douglas fir and State afforestation is largely oriented towards radiata pine (*Pinus radiata* D. Don.). In contrast, New Zealand Douglas fir has always formed an important part of State afforestation but not of other ownerships. Its potential importance in trade between Australia and New Zealand is possibly greater than current acreages suggest, owing to lack of resources in Australia and the established markets for Douglas fir there. Its relative advantage over radiata pine has been assessed as ". . . the Australian market may well be expected to absorb all the Douglas fir that New Zealand can export but it is unlikely that it will absorb a comparable proportion of radiata pine"; and again ". . . it is likely to bring 50 percent higher stumpages" [than radiata pine] (Spurr, 1961). These apparent advantages need to be evaluated and the ensuing discussion deals largely with New Zealand experience in this respect and concludes with a sideration of the desirability of establishing further areas of Douglas fir in Australia.

* Department of Forestry, Australian National University, Canberra.

* Current domestic value in country of origin.

TABLE 1: LONG TERM DOUGLAS FIR IMPORTS INTO AUSTRALIA

AUSTRALIA

Years	Volume[1]				Value[2] f.o.b. basis			
Y.E. 30/6	Million bd. ft	% ex U.S.A.[3]	% Softwood Imports	% All Timber Imports	£1,000 Stg	% Softwood Imports	% All Timber Imports	Av. Value s.stg/100 bd. ft
1936–40	255.0	—	18	17	997	22	20	7.8
1941–45	157.0	14	52	49	1,250	54	52	15.9
1946–50	429.0	41	53	49	8,047	59	49	37.5
1951–55	701.1	50	51	46	22,192	60	43	63.3
1956–60	829.9	43	68	51	28,436	73	51	68.5
1961–62	351.6	—	72	51	12,083	72	60	68.7
1961–65[4, 5]	869.3	44	73	53[5]	30,951	N.A.	N.A.	71.2
NEW ZEALAND								
Y.E. 31/12						c.d.v. basis		
1921–25	55.4	—	67	21	480	54	12	17.3
1926–30	80.2	—	44	25	565	33	14	14.0
1931–35	12.1	—	46	14	84	30	8	13.9
1936–40	24.8	—	57	14	209	40	8	16.9
1941–45	14.4	—	65	18	203	46	12	28.2
1946–50	45.6	—	75	27	1,215	61	24	53.3
1951–55	55.3	—	70	26	1,971	58	20	71.3
1956–60	44.2	—	57	19	1,623	47	14	73.4
1961–62	14.1	—	36	15	485	29	12	68.8
1961–64[7]	27.3	77	35	16	1,006	28	13	73.7

[1]Wilson, 1963.
[2]Wilson, 1964.
[3]U.S. Dept. Commerce, 1941–64.
[4]Division Timber Supply Economics, 1964.
[5]Oversea Trade 1963, 1964. 1965; estimated in part as not all categories have species specified.
[6]Yska, 1963.
[7]New Zealand Forest Service, 1963, 1964, 1965.

TABLE 2: RECENT DOUGLAS FIR EXPORTS FROM U.S.A. TO AUSTRALASIA

Year	Timber Widths								
Y.E. 31/12	Less than 2 in. Vol.[2]	Less than 2 in. Val.[3]	2 in.–5 in. Vol.[2]	2 in.–5 in. Val.[3]	5 in. + Vol.[2]	5 in. + Val.[3]	Total Vol.[2]	Total Val.[3]	%[4]
TO AUSTRALIA									
1959	3,618	98	12,400	85	61,791	62	77,809	67	26
1960	7,924	110	18,820	99	84,898	70	111,642	77	29
1961	5,405	82	11,928	81	31,051	57	48,384	65	18
1962	8,297	89	17,345	89	39,775	63	65,417	73	21
1963	8,149	103	18,354	97	57,746	64	84,249	75	23
1964	7,335	102	19,713	99	60,410	67	87,458	77	24
TO NEW ZEALAND									
1959	115	129	1,917	88	3,973	59	6,005	69	2
1960	64	128	2,394	94	5,586	66	8,044	75	2
1961	239	78	2,758	86	3,732	54	6,729	68	2
1962	76	74	2,197	91	3,753	60	6,026	71	2
1963	188	100	1,652	106	2,754	62	4,594	80	1
1964	156	97	2,080	110	3,568	62	5,804	80	1½

[1]U.S. Dept. Commerce 1959–64.
[2]Volumes in 1,000 bd. ft.
[3]Values in shillings sterling/100 bd. ft, f.a.s. basis; correct to 1 shilling.
[4]Per cent. of U.S.A. Douglas fir timber exports (by volume).

TABLE 3: RECENT DOUGLAS FIR EXPORTS FROM CANADA TO AUSTRALASIA[1]

Year	To Australia Vol.[2]	Val.[3]	%[4]	To New Zealand Vol.[2]	Val.[3]	%[4]
1959	76,063	54	5	2,929	70	Negligible
1960	101,795	57	6	1,610	72	"
1961	81,467	55	5	2,133	67	"
1962	106,773	55	7	1,488	65	"
1963	100,099	57	6	969	63	"
1964	92,143	58	6	1,537	73	"
1965	99,258	58	7	473	66	"

[1]Canada, Dominion Bureau of Statistics, 1959–65.
[2]Volumes in 1,000 bd. ft.
[3]Values in shillings sterling per 100 bd. ft, f.a.s. basis, correct to 1 shilling.
[4]Per cent. of Canadian Douglas fir exports (by volume).

TABLE 4: NEW ZEALAND DOUGLAS FIR EXPORTS TO AUSTRALIA

Year Y.E. 30/6	Totals[1] Volume thousand bd. ft	Value[2] £	Relative value per 100 bd. ft[3] Ex N.Z.	Ex Canada	Ex U.S.A.
1956	Nil	—	—	—	—
1957	216	6	53.5	72.3	74.7
1958	668	21	63.2	64.5	67.3
1959	1,909	69	72.9	58.2	62.0
1960	4,168	159	76.6	71.8	74.5
1961	1,629	53	66.1	71.6	77.3
1962	1,829	54	59.8	59.0	69.3
1963	2,103	65	61.7	65.8	76.7
1964	2,942	101	68.6	69.2	78.2
1965	1,835	61	67.4	71.5	78.5

[1]Overseas Trade 1956–65.
[2]£000 sterling, c.d.v.
[3]Shillings sterling, correct to 0.1 shilling, c.d.v. basis.

TABLE 5: NEW ZEALAND DOUGLAS FIR PRODUCTION

Year Y.E. 31/3	Ex Kaingaroa and Whaka Forests[1] Pulp and Sawlogs[2]	Round Produce Vol.[2]	Round Produce % Production	% Waipa Supply[3]	New Zealand Sawn Timber[4] Vol.	Sawn Timber[4] % of Exotic Cut	State Forest Log Total[2]	Residual Surplus Available for Pulp[2, 5]
1950	114	57	33	33	1.2	0.8	—	Nil
1951	293	173	37	37	1.9	1.0	—	"
1952	329	197	37	37	2.4	1.0	—	"
1953	475	379	44	44	2.7	1.2	—	"
1954	450	452	50	50	3.6	1.5	—	"
1955	647	549	46	51	4.0	1.4	—	"
1956	1,700[6]	493	22[6]	44	3.8	1.3	—	800
1957	1,584	543	26	56	4.5	1.6	—	500
1958	2,060	652	24	47	6.4	2.3	—	450
1959	2,387	638	21	34	6.7	2.1	—	950
1960	2,515	548	18	33	12.6	3.6	......	Nil
1961	2,823	490	15	29	12.3	3.1	—	200
1962	3,012	497	14	31	13.8	3.6	3.5	800
1963	3,585	288	7	15	14.7	3.9	3.7[7]	800
1964	3,950	377	9	15	18.5	4.7	4.3	600
1965	—	—	—	—	24.5	5.2	5.3	400

[1]These two forests produce 90 to 98% of the State Forest Douglas fir supply.
[2]Log volumes in thousands of cu. ft.
[3]Waipa mill was the largest producer of Douglas fir timber until 1956.
[4]Yska, 1963; N.Z. Forest Service, 1964, 1965. Volumes in million bd. ft.
[5]Residual figure, after allowing a conversion factor of 5.0 for sawlogs.
[6]Sales to Tasman Pulp & Paper Co. began.
[7]This figure appears to be an underestimate, as Kaingaroa and Whaka production alone exceeded it.

TABLE 6 : TARIFFS ON DOUGLAS FIR TIMBER IMPORTS

Category	Ex Canada 1960[1]	Ex Canada 1964[2]	Ex U.S.A. 1960[1]	Ex U.S.A. 1964[2]	Ex New Zealand 1960[1]	Ex New Zealand 1964[2]
			INTO AUSTRALIA			
Rough-sawn 6×12 and larger	4.8	7.2	5.6	8–8.8	Free	—
4×6 to 12×6	7.2	12.4	8.0	13.2	Free	—
Less than 4×6	9.6	12.4–24	10.4	14–24.8	Free	14.4
			INTO NEW ZEALAND[3]			
Cross-section of over 150 sq. in., & over 25 ft long	—	7.5	—	8.5	—	—
Other sizes	—	9.5	—	10.5	—	—

Values are in shillings sterling/100 bd. ft.

[1]Commonwealth of Australia, 1960.
[2]Commonwealth of Australia, 1964.
[3]New Zealand Tariff, as amended, 1/1/1966.

TABLE 7: COMPARATIVE PRICES OF DOUGLAS FIR TIMBER

Timber Dimensions (in.):	4×1	4×1⅝	4×2 Studs	4×2 to 12×2	Export prices to Aust.[9]
New Zealand (domestic):				4×2 12×2	
North Island[1]	60.50	—	—	85.5–115.5	—
South Island[2]	59.25	—	—	75.5–96.75	78.53
Canada[3]	—	—	38.57[4]	46.42[5] 47.14[6]	58.25
United States[7]	41–68.00 (No. 3 to No. 1 common)	53–54.00 (Standard and better)	44.00	56.7[8] (No. 1 common)	77.25

All prices are in shillings sterling/100 bd. ft.

The New Zealand timber is sold ungraded, and Canadian shipments are mixtures of grades; hence only broad comparisons can be made from these figures.
[1]New Zealand Forest Service, 1964a. Price free on rail.
[2]New Zealand Forest Service, 1965b. Price free on rail.
[3]Cooper Widman, 1964.
[4]60/25/15 — namely 60% construction, 25% standard, and 15% utility grades; free at shipside.
[5]75/25 — 75% construction, 25% standard; at mill.
[6]60/20/20 — grades as for (4), price at mill.
[7]From Table 16.
[8]FAO, 1965. Mean of average price for 1964 at mill in U.S.A.
[9]"Current domestic value in country of origin" basis.

AUSTRALASIAN RESOURCES OF DOUGLAS FIR

The extent of Douglas fir planting is given in Table 8. The New Zealand figures were checked from three sources:

(1) The age-class distribution as given to the 1957 British Commonwealth Forestry Conference (Weston, 1957) and supplemented by figures from subsequent annual reports (N.Z. Forest Service, 1957–65). These gave a total area of 63,241 acres in State forests, plus 2,000 acres privately owned.

(2) New Zealand's planted area summary in the 1957 Annual Report, together with later figures — giving a total area of 63,954 acres on State forests.

(3) Exotic forest survey figures based on accurate boundary relocation gave an overall area of 62,436 acres in State forests, plus 2,900 acres privately owned (T. Wardrop, pers. comm.).

Clearly, the area established is about 62,500 acres of State and 3,000 acres of private ownership. Australian statistics are less definite, the available data giving a total area of about 3,500 acres in State forests (Table 8). Since 1951 the rate of planting has increased in both New South Wales and New Zealand (Table 9), and the New Zealand post-1960 figures would have been greater still if nursery programmes had not been upset by the untested use of simazine weedkiller, to which Douglas fir proved susceptible. The reported figures of 2,944 acres planted per year on New Zealand State forests from 1956 to 1960 (Spurr, 1961) is too high — an annual acreage of 2,500 was not achieved until 1965. Recently it has been reported that about 500 acres per year will be planted

TABLE 8: AREAS OF STATE DOUGLAS FIR PLANTATIONS

(in acres)

Year Planted	New Zealand acres[1]	New Zealand acres[2]	%	New South Wales acres[4]	Victoria acres	Tasmania acres[7]
1901–10	1,184	220	0.3	—	—	—
1911–20	1,184	960	1.5	—	—	—
1921–30	18,963	19,130	30.2	73	More	183 by
1931–40	15,681	14,350	22.7	4	than	1956
1941–50	2,822	3,520	5.6	Nil	2,000[5]	—
1951–60	—	13,110[3]	20.7	89	Nil[6]	—
1961–65	—	11,951	18.9	1,080	Nil	—
Total	—	63,241	100.0	1,246	2,000	183

[1]New Zealand Forest Service Annual Report 1957 — Appendix VI.
[2]Weston, 1957.
[3]New Zealand Forest Service Annual Reports 1951–65.
[4]New South Wales Forestry Commission, Annual Report 1964, and internal reports.
[5]Forestry Commission of Victoria 1957.
[6]Forestry Commission of Victoria Annual Reports 1958–64.
[7]Forestry Commission of Tasmania, 1957.

Areas in other Australian states and territories are negligible.

TABLE 9: RECENT AFFORESTATION WITH DOUGLAS FIR

Year	*New Zealand* State Forests *Area (acres)*	*New Zealand* State Forests *% Afforestation*	*New Zealand* *Major Private Companies* *Area*[1] *(acres)*	*New South Wales* State Forests *Area (acres)*	*New South Wales* State Forests *% Afforestation*
1951–55	4,140	16.5	—	Nil	—
1956–60	8,970	24.6	410	89	0.3
1961–65	11,951	15.3	2,120	1,080	4.4

[1]This area is understated, not all firms replied.
Afforestation with this species under the Farm Forestry Scheme has been negligible.

in New South Wales (Anon., 1965a). There is a slight change in the published policy in Victoria where it has been reported that further establishment of Douglas fir would not take place (Forests Commission Victoria, 1957), but subsequent reports (Forests Commission Victoria, 1962–4) indicate that it would be considered for suitable sites.

Geographically, about two-thirds of the total area of Douglas fir planting in New Zealand is within 60 miles of Rotorua, in areas which initially supplied the Waipa State Mill, and subsequently the Tasman Pulp & Paper Co. also.

QUALITIES OF AUSTRALASIAN DOUGLAS FIR TIMBER

The end use of Douglas fir timber, when the tree is grown as an exotic to at least 50 years of age, is essentially as framing timber, with minor outlets for round produce and for such uses of board as laths, tile battens and in farm buildings. The contrast in density between the early and latewood of an annual ring (an increase of 100% or more according to Harris & Orman, 1958) together with a relatively low number of rings per inch produce inequalities of texture that are unsatisfactory for most dressed timbers. While quarter-sawn edge-grain stock from slow (seven or more rings per inch) and evenly grown logs may, if clear of knots, be suited for high-grade flooring and joinery, it is unlikely that this will be grown deliberately in New Zealand plantations. It would require too long a rotation. For example, on Site Quality I (Duff, 1956) it would be possible to prune to 18 ft on a tree of 36 ft top height within 15 years, and the diameter/age regime should then ideally be:

Approximate d.b.h.o.b.	*Age*	
5.0 in.	15 yr	Butt log pruned to 18 ft in three lifts
7.0 in.	22 yr	Bark and stubs excluded; clearwood formed
17.0 in.	57 yr	Tree grows at seven rings per inch

At 57 years of age a 5 in. shell of clearwood would be formed at d.b.h. from which it might be possible to saw clear 4 × 1 timber from the butt logs. To reach a more reasonable d.b.h. of 21 in. a perfectly tended stand would take 80 years, which is twice the time that radiata pine requires to produce first-class finishing timber, in clear grades (Reid, 1953). Even with heavy thinning, the 100 largest stems per acre of Douglas fir after 50 years of age will grow only at six rings or more per inch (Spurr, 1963). Greater volume of finishing grades could be produced from shorter rotations of radiata pine. The appropriate balance of finishing timber from Douglas fir has been indicated by the statement: "it is desirable to prune a small percentage of the trees to be handled on long rotations to provide clears for joinery . . . and large diameter logs for plywood" (Reid, 1962).

The requirements for satisfactory framing timber are strength, straightness and stiffness, which depend on the basic density and shrinkage characteristics of the stem wood as well as the size and condition of the branches. Investigations have been made of the basic density characteristics of New Zealand-grown timber of Douglas fir, and it was found to be as dense and as strong as North American material from second-growth stands (Harris and Orman, 1958). Their analysis included silvicultural considerations and recommended an initial spacing of 6 × 6 ft, with subsequent thinning to maintain not less than five rings per inch, in order to achieve a desirable basic density and a reasonable growth rate (Harris and Orman, *op. cit.*). In practice, much of the Douglas fir established before 1923 and after 1940 has been planted at 6 × 6 ft; 8 × 8 ft spacing was generally used in the intervening years. It has been suggested that, as the differences between these spacings tend to disappear with age, ". . . economic analysis may well eventually point to the 8 × 8 ft as being the most profitable in that the reduced necessity for early thinning might more than counterbalance any eventual reduction in wood quality" (Spurr, 1961).

Inequalities of wood properties affect lamination to some extent, as scarf joints between late and early wood cause greater variability in the properties of random joints; although this effect can be minimized by good design (G. Stanger, pers. comm.).

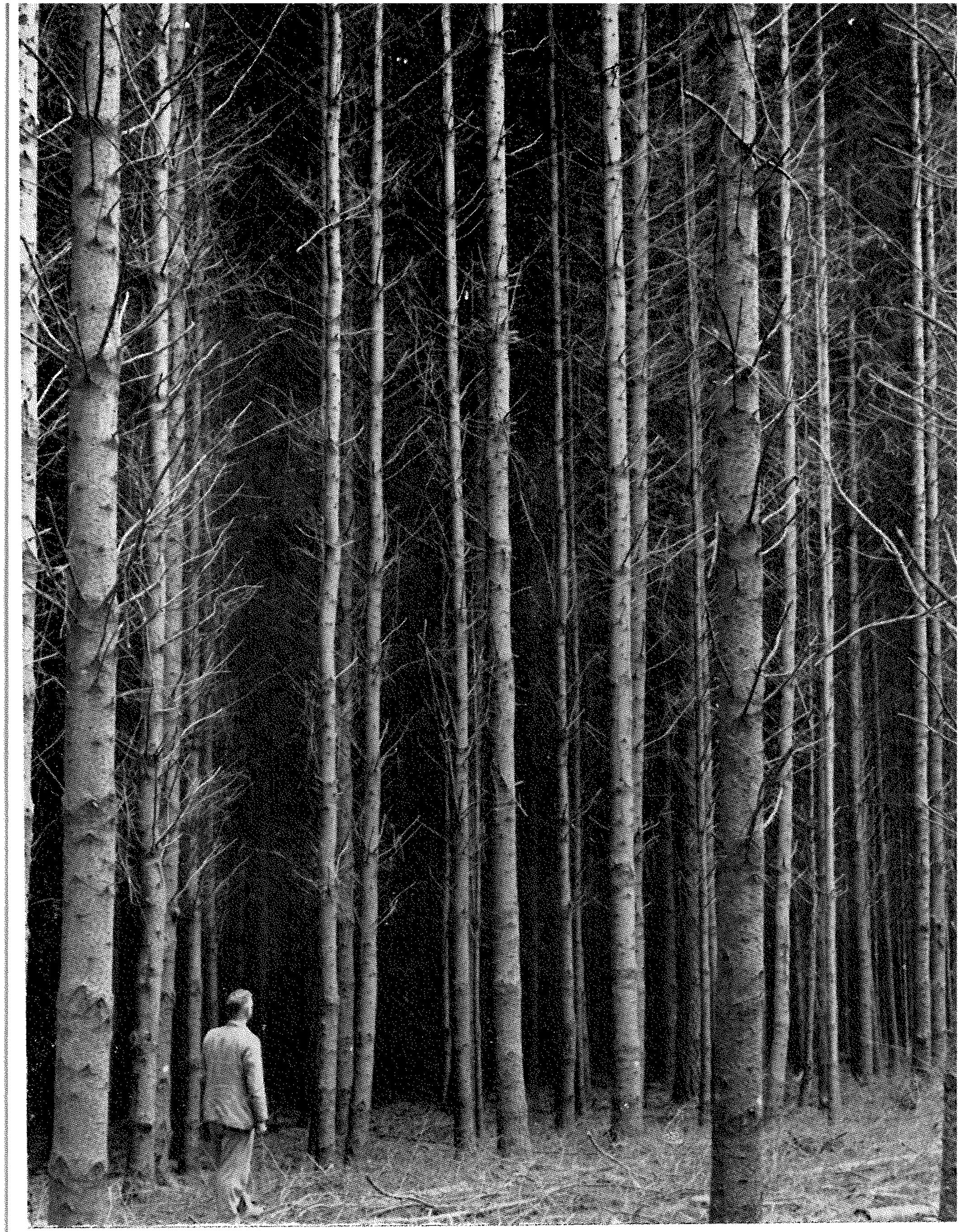
The qualities of Douglas fir for round produce are discussed later. Its relative imperviousness to preservatives, apart from diffusion processes, has not proved to be a disadvantage as yet.

THE DEVELOPMENT AND TENDING OF NEW ZEALAND DOUGLAS FIR

For New Zealand a succinct account of silviculture is available (Weston, 1957) together with supplementary information (Spurr, 1961; Hinds, 1962). Yield figures for unthinned (Duff, 1956) and thinned stands (Spurr, 1963) have been published, and further data on timber quality are available (Hinds and Reid, 1957). The following discussion is concerned primarily with the economics of forestry and the course of future trade, together with those silvicultural details not fully dealt with in earlier work. To date, the silviculture has been ideal if the end use is to be framing timber. The stands in State forests were generally well planted and resulted in relatively full establishment. Failed areas were few and soon showed up either as complete failures or by having small (4 to 6 ft) trees which persisted as such. In contrast, radiata pine will often survive on severe (namely, frosty) sites and, although badly malformed, will continue to grow taller; the resultant trees and stands possessing excessive malformation, often with 40 to 60% of the stand volume accounted for by malformed trees. Karioi forest, in the central part of North Island, provides a documented example of the different development of the two species, since a series of trial plots were established there in 1927–31 on open, fertile sites subject to heavy frost. Over the first ten years, the Douglas fir on two sites was reported as a total failure: "a few scattered trees survive but have made little progress" and "the Douglas fir are to be abandoned" (Ohakune District local research register). However, as shelter from adjacent stands of hardy pine species increased, the Douglas fir trees recovered and are now 90 ft tall. Details of reports of early development are given in Appendix 1. Comparable, but undocumented cases occurred elsewhere — *e.g.*, compartment 1088 in Kaingaroa forest. Provided air drainage is good and exposure limited, Douglas fir has higher altitudinal limits than radiata pine and is less susceptible to snow damage. These characteristics have not, as yet, been important in New Zealand in complementing the range of sites available to Douglas fir, but the reverse seems true in recent New South Wales afforestation. The most extensive commercial stands at higher altitudes in New Zealand are again in Karioi Forest and approach the 3,000 ft contour. On these sites development of radiata pine is excessively malformed. Undoubtedly the generally better stem form of Douglas fir, with absence of multiple leaders and less gross branching characteristics, are major advantages over untended radiata pine.

Row-by-row mixtures of Douglas fir with either larch (*Larix decidua* Mill.), lodgepole pine (*Pinus contorta* (Dougl.)) or Corsican pine (*Pinus nigra* Arn. (Laricio)) have been used occasionally. The mixture with larch is used to increase the acreage of Douglas fir when nursery stock is locally scarce; the larch is eventually overtopped, despite its initially faster height growth, and a largely self-thinning crop develops. Similar reasons of shortage of planting stock lead to mixture with lodgepole pine, but the outcome is less certain because the height growth of a good strain of the pine may be greater. The management policy is to favour "the best species" — axiomatically assumed to be Douglas fir — and to poison out the pine. Further reasons for mixtures, more especially with Corsican pine, are to provide an intermediate yield of pine posts from country of easy topography, and to have a "self-thinning" mixture on steeper areas, where this pine is usually overtopped on all but the most difficult sites. Mixtures with pine species occupy only a minor part of the areas currently afforested.

In pure stands the canopy is generally complete by top height 20 to 25 ft and lack of mortality, when combined with good establishment, leads to rapid suppression of the butt log branches and their relatively early death. Apart from branches on wolf trees and on open grown trees in canopy gaps, branch diameter is usually



Unthinned stand of Douglas fir at age 33 yr. Planted in 1921 at 6 × 6 ft spacing; low pruned in 1937. (Cpt. 1123 Kaingaroa S.F.).

N.Z. Forest Service photo, by J. H. Johns, A.R.P.S.

less than 1.5 in. in most stands. Height growth, once canopy is complete, is fairly rapid (Duff, 1956) and stem mortality does not seem to be as severe as in second growth stands in the U.S.A. (Table 10).

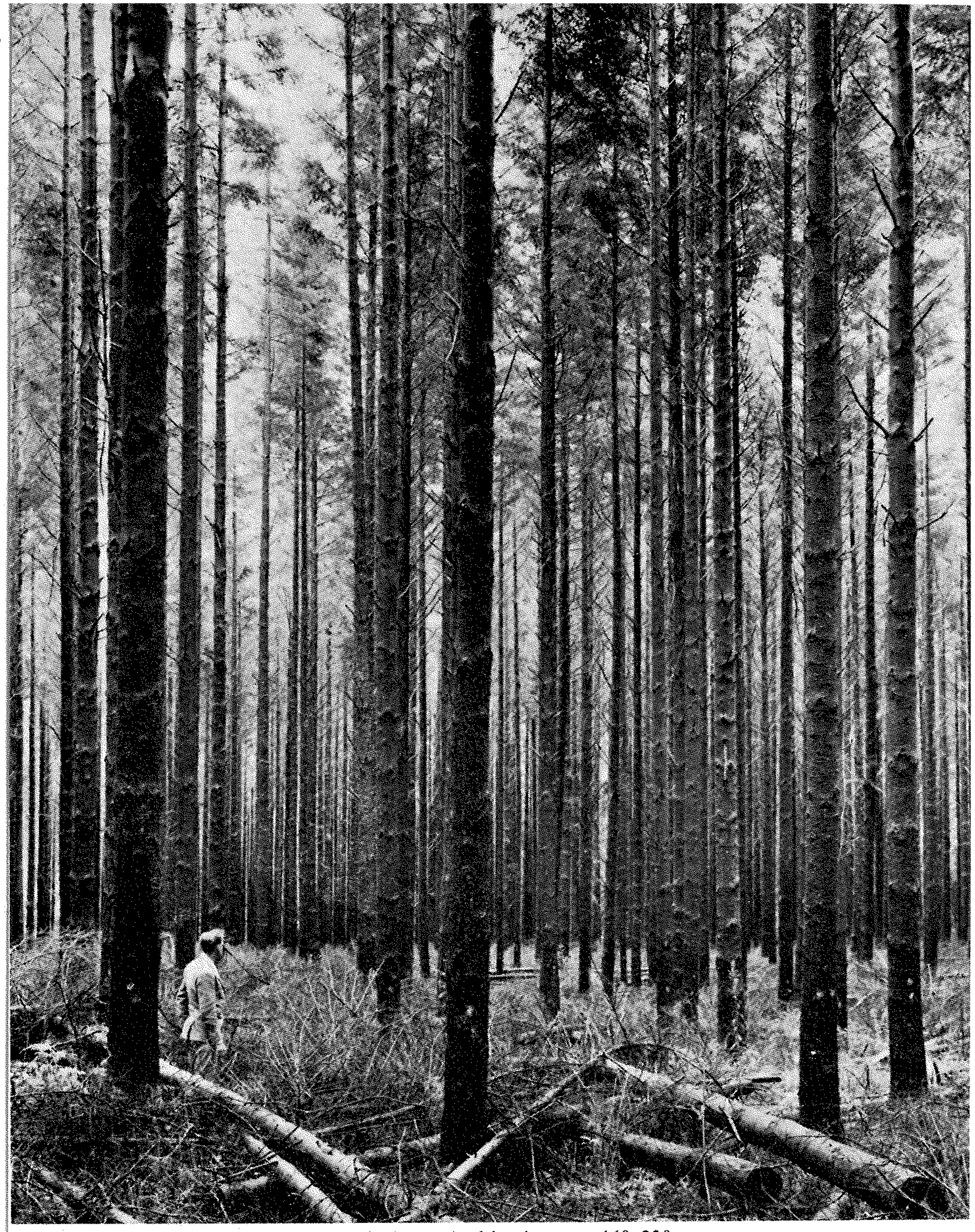
TABLE 10: RELATIVE STOCKING — NEW ZEALAND AND PACIFIC NORTH-WEST DOUGLAS FIR

Age Years	*Site Spacing*	*New Zealand*[1] *S.Q. I* *6×6 ft*	*8×8 ft*	*Pacific N.W.*[2] *S.I.180* *Fully stocked*	*S.I.190*	*New Zealand S.Q. II* *6×6 ft*	*8×8 ft*	*Pacific N.W. S.I.150 Fully stocked*
10	....	1,120	590	—	—	1,150	610	—
20	....	850	490	756	654	990	550	1,210
30	....	590	370	483	408	770	450	735
40	....	450	300	335	282	620	380	510
50	....	380	270	248	208	530	340	377

All stocking figures in stems per acre.
[1]Duff, 1956.
[2]McArdle *et al.*, 1961.

The original New Zealand figures for top height at age 50 (Duff, 1956) were conservative (Spurr, 1963) and age 40, rather than 50, is probably a better age for inter-country comparisons. The effect is a conservative bias in taking American Site Index 180 as equivalent to the New Zealand Site Quality I; if comparisons are made with still higher quality American sites, the relatively greater stocking in New Zealand is even more marked. Furthermore, the stocking in unthinned New Zealand sample plots is, in fact, greater than the earlier figures suggest. Mortality is markedly less than in unthinned radiata pine stands in most areas, and hence thinning can be delayed to age 40 to 45 without undue loss in volume.

The branching characteristics have been reported as horizontal (Hinds & Reid, 1957) in contrast to the generally angular branching of radiata pine, but it is likely that the pendulous nature of the relatively thin branches gives this effect; the branches where they leave the trunk are at angles comparable to those of pines. This is exemplified in published photographs (Plate 4 of Weston, 1957; Plates 1 and 3 of Harris and Orman, 1958; and in plates of the Annual Report, New Zealand Forest Service, 1955). Consequently, degrade of wood due to crescents of bark on the upper side of knots does occur but, since the major use is framing and not boards, this defect is of less consequence than in radiata pine. The branching pattern has been described as lacking defined nodes (Reid, 1963) and, in general, the branching is less clustered than, for example, Corsican pine. In a minority of trees the branching is more or less in annual clusters but, even in these, large numbers of small branches (0.1 to 0.5 in. diameter) occur between major whorls. The net effect is to greatly reduce the number of boards which it would be possible to grade as equivalent to Factory (New Zealand Standard Specification 169) or as North American Shop grades; again, as the timber is for framing, this is not important. The more dispersed nature of the branching pattern results in less chance of concentration of defects and,



Douglas fir on completion of thinning to 160–220 stems per acre 39 yr. Cpt. 1113, Kaingaroa S.F. See frontispiece for present dimensions.

N.Z. Forest Service photo, by J. H. Johns, A.R.P.S.

TABLE 11: GREEN CROWN LEVELS IN NEW ZEALAND DOUGLAS FIR

		Unthinned Plots												Heaviest Thinned Plot
		Age 20–29			Age 30–39			Age 40+						
Locality and Plot No.	Spacing (ft)	Age (yr)	G.C.L. (ft)	Top Height (ft)	Age (yr)	G.C.L. (ft)	Top Height (ft)	Age (yr)	G.C.L. (ft)	Top Height (ft)	Years Recorded (yr)	Total Ht Growth (ft)	Loss of Crown Depth (ft)	Green Crown Level at Last Comparable Measurement
Kaingaroa R20	6×6	26	31	70	38	75	102*	—	—	—	12	32	44	70
Kaingaroa R22	8×8	25	20	67	31	44	85*	40	82	116	15	49	62	65
Kaingaroa R23	8×8	29	48	84	38	80	106*	—	—	—	9	22	32	66
Kaingaroa R24	8×8	21	24	55	—	—	—	—	—	—	—	—	—	—
		27	41	68	36	86	104*	—	—	—	15	49	62	50
Kaingaroa R38	8×8	20	23	55	—	—	—	—	—	—	—	—	—	—
		29	54	84	—	—	—	—	—	—	9	29	31	45
Kaingaroa R214	8×8	19	17	49	27	42	73	—	—	—	8	24	25	—
Karioi WN57	8×8	28	37	70	31	39	77	—	—	—	—	—	—	—
		—	—	—	34	46	84*	—	—	—	6	14	9	35
Golden D. N100	8×8	—	—	—	32	57	96*	—	—	—	—	—	—	—
Hanmer C88	8×8	26	17	54	35	39	67	—	—	—	9	13	22	—
Hanmer C112	8×8	25	23	61	35	52	83	—	—	—	10	22	29	—
Dusky S37	8×8	27	25	58	31	40	66	—	—	—	—	—	—	—
		—	—	—	37	59	86	—	—	—	10	28	34	48
Dusky S39	6×6	27	37	70	30	39	78	—	—	—	—	—	—	—
		—	—	—	37	66	90	—	—	—	10	20	29	—
Tapanui S44	8×8	26	28	65	35	59	92	—	—	—	9	27	31	—

* Extrapolated from previous measurements.
Source: Unpublished data, New Zealand Forest Research Institute Permanent Sample Plots.
Definitions: Green Crown Level: The average height, for a number of sample trees predominants, to a point on the stem between the lowest green branch and the lowest green whorl, but not necessarily midway. (H. Beekhuis, pers. comm.)
Top Height: The mean height of the 100 trees of largest diameter per acre.

with the small branch sizes of the timber milled to date, favours the use of the species for framing.

Details of the development of the green crown level in New Zealand Douglas fir are given in Table 11; in unthinned stands the base of the green crown is at 30 to 40 ft by about top height 70 ft, and by top height 100 ft it is approximately 75 ft. The critical age for the rapid and technically desirable death of the lower crown is between 30 and 40 years. As with natural stands in North America and in European plantations, branches are strongly persistent and natural pruning is as slow as, or slower than for radiata pine (Fenton and Familton, 1961). Until 1962 the great majority of thinning operations had occurred at or after age 40, and hence in the three or four lowest sawlogs the branches were dead and relatively small. This condition was therefore fixed for any subsequent yield from the most important part of the remaining trees. Much of the timber sawn from top logs (namely, from the green crown of second thinnings at age about 55) has been of poor quality, being degraded by large live knots of more than 2 in. diameter. The remarkable reaction of Douglas fir to delayed and very heavy thinning (Spurr, 1961) is achieved at the inevitable cost of enlarged branches in the remaining crown above about 75 ft. If the species is to be grown on long rotations, timber from these upper log-height classes will occur more frequently and will be akin to box grade of radiata pine. Economically, this material may be more than compensated for by the excellent grades of framing from the lowest three or four log-height classes. In calculating the value of long rotations, prolonged height growth and the ensuing development of further heavy branches after thinning will have to be assessed against increased log diameters in the three or four lowest logs. Removal of the lower dead branches by falling trees during thinning operations certainly reduces the incidence of future defects, provided a sufficiently long time interval elapses between thinning and clear felling (Fenton, 1966); it is rarely sufficient to produce long clear lengths, but this is of less importance for framing than for board timber.

The persistence of tree branches and the dense shade under the canopy make marking difficult in thinnings unless stands are 0/8 ft pruned. Douglas fir bark is thin on young trees and this, combined with a large number of short, wire-like branches (1 ft long and up to 0.2 in. diameter) make secateurs preferable to saws for pruning. Spurr (1961) and Reid (1962) have pointed out that pruning is desirable but not essential in this species, and an internal Forest Service directive rates its priority below that of pine species. This view is entirely correct but, as the fragmentary data assembled in Table 12 show, up to 1963 a far greater percentage and a physically greater area of Douglas fir than of radiata pine had been pruned in State forests. Selective pruning 0/18 and 8/18 ft of 25- to 30- and occasionally 35-year-old trees was carried out throughout the 1950s despite labour shortages, while on many forests young radiata pine remained unpruned. Although it has been advocated that even old (75 years) Douglas fir can be pruned at a profit (Smith, 1956) New Zealand experience has shown delayed pruning is not very profitable if recovery of clear boards is sought (*e.g.*, Fenton, 1966).

TABLE 12: TENDING — NEW ZEALAND DOUGLAS FIR IN STATE FORESTS

Year Y.E. 31/3	Pruning to 18–20 ft: Kaingaroa Forest[1]	Pruning to 18–20 ft: All New Zealand State Forests[1]	Production Thinning: Kaingaroa Forest[1]	Production Thinning: All New Zealand State Forests[1]	% State Exotic Log Production	% all Exotic Forest Log Production[3]
1945–50	627	N.A.	305	N.A.	—	—
1951–61	14,458	N.A.	3,460	N.A.	—	—
1962	210	261	459	N.A.	7.8	3.0
1963[2]	0	150	438	707	8.5	3.1
1964	0	449	665	749	7.0	2.8
1965	0	—	1,031	1,122	7.9	3.5

[1]Areas in acres.
[2]New Zealand Forest Service, 1963–65; corrected figures for 1963 are given above.
[3]Figures decreased by effect of Japanese log trade in radiata pine.

Some additional strength in framing timber could result 20 years after pruning, if modified sawing patterns were used, but this would involve increased sawing cost and lower conversion. It would not affect the stiffness of the timber (Sunley, 1962). Possibly rotary veneer would be an outlet to justify the cost of pruning since some Canadian data suggest face veneer is recoverable within 25 years of pruning (Smith and Walters, 1961).

Thinning with extraction of Douglas fir, on country of easy topography, has hitherto been delayed until a large volume could be cut. A range of operations is shown in Table 13. On steeper country tractors are still cheaper than haulers, but the thinning intensity is greater. Steep country results in higher costs, particularly if haulers are used, and residual stocking is lower. By thinning at age 30, the reduced yield is associated with both higher costs and lower realizations, resulting in minor or even negative returns. The obvious disadvantage in the management of Douglas fir is the long time interval before thinning is both profitable and technically desirable. On one private forest, wider spacing allows thinning at age 24 (Spurr, 1961). The resultant stands may produce coarser timber than from later thinnings of more closely spaced stands but this material has been accepted to date by the market.

In Southland a few limited areas of 40- to 50-year-old stands have now been thinned three or four times, using horses for extraction. Yields have varied from 1,200 to 2,000 cu. ft per acre and the costs of 7d to 10d per cu. ft have been comparable with those of mechanized operations despite the lower volume yields.

Thinning intensities have been heavy, partly to recover the operating costs of the tracked tractors and mechanized loaders used to date. The use of cheaper equipment such as wheeled farm tractors has not been followed for extraction operations in New Zealand, despite the generally favourable topography of the stands thinned to date. The volumes extracted per acre have generally been inflated by clear fellings along road lines and yields of 4,500 to 5,000 cu. ft per acre, as reported by Spurr (1961), are likely to be more accurate than the 5,000 to 7,000 cu. ft shown by the earlier internal figures (Table 13).

The extent of thinning, the volumes extracted and the estimated end use of the material are shown in Tables 5 and 12. Thinning on country of easy topography has been, and is, profitable not because all costs are lower than for other species, but because returns are higher. Nevertheless, some costs are lower, notably hauling, where the lower green weight of Douglas fir allows greater volumes on tractor hauls and logging trucks than for pine species; green weights are 47, 58 and 62 lb/cu. ft for Douglas fir, radiata and Corsican pine, respectively (Hinds and Reid, 1957).

UTILIZATION OF THE DOUGLAS FIR PLANTATIONS

From 1941 until the mid 1950s Douglas fir and larch (*Larix decidua* Mill.) dominated the round-produce market, which was of small scale, and pines were rarely used. This was due both to the difficulty of seasoning pine rounds and to the presence of three — later two — State-owned treatment plants using oil-soluble

TABLE 13: TYPICAL THINNING COSTS, DOUGLAS FIR IN NEW ZEALAND STATE FORESTS

Year	Forest	Compt.	Age	Spacing (ft)	Volume per acre Extracted[1] (thousand cu. ft)	Total Yield of Operation (thousand cu. ft)	Stocking S.P.A.[2] Initial	Stocking S.P.A.[2] Residual	Man-hour Production (cu. ft)	Topography	Extraction Method	Costs per cu. ft on Skids (d)
1964	Kaingaroa	1104	41	8×8	5.5	374	400	160	54	Rolling	Tractor	8.9
		1122	41?	6×6	10.0	225	400 [sic]	160	49	Rolling	Tractor	9.3
		1120	53	6×6	9.5	179	525	90	21	Steep	Hauler	17.7
		697	30	8×8	6.5 [sic]	120	390	170	31	Rolling	Tractor	14.2
	Dusky	16	39	8×8	4.0	148	700	200	42	Easy	Horse	12.6
1963	Kaingaroa	1097										
		1102	41	8×8	5.5	826	600	140	66	Undulating	Tractor	6.9
		1123C	43	6×6	5.8	98	860	220	18	Steep	Hauler	20.5
		1120B	43	6×6	N.A.	141	860	220	23	Steep	Hauler	16.2
		1095B	41	8×8	N.A.	89	500	200 [say]	24	Steep	Hauler	16.5
		1123	42	6×6	6.5	100	650	160	51	Undulating	Tractor	9.0
		1149	40	8×8	7.6	467	460	120	64	Rolling	Tractor	7.8
		697	30	8×8	3.0	15	400	200	26	Flat	Tractor	10.9
	Whaka	4A	58	2nd thin.	2.7	222	127	63[3]	87	Flat	Tractor	7.0[4]
		7C	57	2nd thin.	4.7	47	220	60–100	65	Steep	Tractor	7.9
1962	Kaingaroa	1102	39	8×8	5.5	1,044	400	150	70	Flat to rolling	Tractor	6.7
		1123	41	6×6	5.8	133	860	220	17	Steep	Hauler	20.7

[1]These yields are estimates supplied at the time; they are probably overstated.
[2]Figures are only estimates.
[3]Figures are high.
[4]Costs inflated by rate of bonus paid.

Source: Unpublished figures, New Zealand Forest Service. All operations are on a bonus or piecework basis; the most accurate costs are those of the larger scale operations.

preservatives. These plants were sited near forests which included stands of larch and Douglas fir. In 1955 one of these was replaced by a large pressure plant, which also used only oil-soluble preservatives. In the mid 1950s, competition with sawn timber treated by cheap diffusion methods caused pressure plants using multi-salt water-soluble preservatives to break into the round-produce market, which until then had been almost monopolized by round produce treated at the two State-owned oil-soluble plants (Fenton, 1962). The importation, through the 1950s, of hardwood posts — largely from New South Wales — at the same time that "hundreds of thousands of acres were crying out for thinning" (Hinds, 1962) illustrates strikingly how slowly the treatment of pine round produce started, although, once under way, progress was very rapid. Now there are over two hundred widely distributed treatment plants utilizing pines, while only one further plant — in addition to the original two — is available to treat Douglas fir.

However, the presence of a very good and relatively unchallenged market for posts and poles was a major reason why the thinning of Douglas fir was profitable initially — the price of the end product was not controlled and good profits (stumpages) could be made from round produce (Fenton, 1962). Owing to the peculiarities of the treatment industry at the time the produce was marketed, it was then fair to say "natural round thinnings from Douglas fir are a far more easily marketed item than thinnings from *P. radiata*" (Reid, 1953). The proportion of thinnings utilized for round produce from Kaingaroa (which with Whaka forest was the major source of supply) is shown in Table 5. Today, in areas other than those supplying the two State plants and one large private plant, the situation is reversed. The pine round produce is easier to utilize as an intermediate crop, and profitability falls as the thinning of Douglas fir extends to forests not supplying the State plants, and round-produce markets are unavailable; this reversal of circumstances has occurred within ten years (compare Reid, 1953, with Reid, 1962). Further, the situation is approaching where pole supplies from Douglas fir will lapse, owing to limited planting in the 1930s (Fenton, 1962) and failure to retain subdominants in thinned stands to fill the gap. It is possible that pine will replace Douglas fir in the future pole market; the reversal of opinion to favour pine poles has been recent, and is based on changes in technology.

The actual merits of Douglas fir in New Zealand as a round product are, of course, high; but comparisons with pine (given in Table 14) are difficult to finalize. Recent development of the oscillating pressure method of preservation, which has marked advantages for treating large cross-sections of pine (New Zealand Forest Service, 1965) may give a decisive lead to pine. Failures in treated Douglas fir poles to date have usually been traced to poor penetration, deriving partly from inadequate seasoning. It is still debatable what constitutes a sufficient degree of penetration, but customer preference may change to the more deeply penetrated pines. The idea of wider spacing resulting in wider sapwood "so that posts may be treated throughout" (Spurr, 1961) is incorrect, since increases in the width of sapwood over the almost universal width of 0.4 in. required by specification does not improve the

TABLE 14: RELATIVE MERITS OF DOUGLAS FIR AND RADIATA PINE AS ROUND PRODUCE

	Douglas Fir	*Radiata Pine*
Form:		
Posts	Generally good.	Usually adequate — larger branches.
Poles	Generally good.	Usually rough, except from specific — usually phosphate deficient — sites, where form is good.
Strength:		
Poles	Good, if treatment temperature and pressure are not severe.	Adequate (Hellawell, 1965). Both species require reasonable care in peeling and preparation.
Air Seasoning:		
Posts	Easy — no decay.	Usually adequate in summer.
Poles	Easy — no decay.	Summer only; preferably in covered stacks.
Preservative	Oil-soluble only.	Oil- or water-soluble.
Penetration	Difficult; minimum specification 0.4 in. in 70% of pieces.	Easy in sapwood which can be completely treated.
	Heartwood impervious.	Heartwood impervious.
Preservative loading	Reasonably easy to achieve; is high in treated zone.	Easy to achieve.
Costs	Higher preservative costs.	Fairly high seasoning risk — require covers in damp climate.
Limitations	Oil-treated poles generally unacceptable in urban areas. Only three treatment plants available.	Water treated material heavy, unless Lowry process used, and requires reseasoning.

treatability of the round; in fact, the amount of pre-treatment seasoning required is increased.

Sales of round produce enabled the major Douglas fir thinning operations to benefit from a profitable diversion of small material from the sawmill. Contemporaneously, small pine sawlogs had still to be converted to low-grade timber at a heavy cost. Other important effects included "a fillip to the interest and morale of forest staff" (Hinds, 1962) and the beginning of piecework rates and other incentive schemes to stabilize the labour force; these effects linked together Douglas fir and profit in New Zealand forestry. Throughout the 1950s, by contrast, pine stands remained a source of net expenditure, apart from clear felling operations.

Douglas fir sawn timber was as favourably placed as round produce when, from 1950, thinnings first found a steady market. Although Douglas fir production increased steadily, until it comprised 5% of the 1965 exotic cut, the overall volume reaching the market has been small, the balance being almost all of pine (Table 5). The figures are not entirely accurate as mills included

some larch timber in with Douglas fir. Such a practice is damaging to export and domestic trade because, although larch combines the highest density with the best branch characteristics of the New Zealand exotic timbers, enough of it is subject to excessive distortion on drying to make general acceptance difficult. With most old (40 yr) Douglas fir stands in State forests concentrated near the two State mills, the Forest Service produced the bulk of the timber until the Tasman Pulp & Paper Company began sawmill operations early in 1956. The volume of Douglas fir timber on the market was too small to render it subject to price control and this, together with its name, the price of equivalent imports, and its intrinsic good quality for framing, enabled the local material to be sold at a price margin above that of pine species. Although it was earlier thought to be susceptible to *Anobium,* it is now found that preservation against this insect is unnecessary. Hence it possesses a further advantage — the main authority providing home finance, the State Advances Corporation, specifies that pine building timber should be preservative treated while Douglas fir can remain untreated; at least half of most cross-sections of Douglas fir timber are of *Anobium*-resistant heartwood. The same authority specifies smaller sizes of (ungraded) Douglas fir than of radiata pine in such positions as sub-floor joists. In Australia, the Division of Forest Products recommends the two species for framing uses on the basis of "Radiata pine . . . sawn full to size should be used in the same nominal sizes as Douglas fir (which is cut scant) if . . . unseasoned, and provided they are graded to equivalent grading rules. In the dry condition radiata pine should be interchangeable with unseasoned Douglas fir of the same grade" (Anon. 1966). Radiata pine's success as an exotic has caused a re-examination of its qualities in its native California, where it ws recently assessed by being equivalent to Douglas fir as a structural timber (Cockrell, 1959).

A major advantage of Douglas fir was that it could be sold ungraded, and so the problem of disposal of low grades did not arise. At the same time, the sawn material originated from relatively uniform logs — the larger thinnings of 35- to 40-year-old stands established at 6 × 6 ft and comprising, in the main, the suppressed, subdominant and low co-dominant crown classes. Sawn, these represented the best of the Douglas fir timber of that age class as, wood density considerations apart, these trees had the smallest branches and the shallowest green crowns. Poor quality Douglas fir timber is inferior for most uses to radiata pine (Reid, 1962) but proportionately little was present in timber from these first thinnings.

The sustained sale of New Zealand-grown Douglas fir in Australia began in 1957, and grew quietly until a strike on the American north-west coast in 1959 presented a most favourable marketing opportunity in Sydney. A demand arose for New Zealand Douglas fir framing which was shipped in 3 and 4 × 2 in. and 6 and 8 × 4 in. sizes (New Zealand Forest Service, 1960). This material had an advantage due to tariff differentials, although naturally the large baulks of the North American trade could not be matched from the New Zealand stands then available. "New Zealand exporters created considerable goodwill by refraining from taking advantage of the shortage. However, as with construction grade (of radiata), orders slumped immediately Canadian Douglas fir began to arrive" (New Zealand Forest Service, 1960), and have not been maintained on a comparable scale since. Some slight increase in price did, in fact, seem to occur, as shown in Table 4, but this was probably due to the export of larger sizes; a positive price size differential exists in New Zealand. There was a diversion of roundwood from pulp to sawtimber, and an overall increase in Douglas fir production in 1954–60.

Douglas fir began to be marketed in New Zealand under a set of peculiarly favourable economic conditions which, together with the quality of the material produced, resulted in a generally profitable series of operations, as long as land of easy topography was worked. It received a misguided priority in pruning, owing to lack of appreciation of timber qualities and end use requirements despite clear leads on the subject (Reid, 1953) and at a cost of further neglect of radiata pine stands. The extensive pruning of Douglas fir at that time emphasizes three trends which have influenced New Zealand exotic tending since it began on an appreciable scale after 1945:

(1) Only Douglas fir was worked profitably in thinning operations, and this led to a concentration of effort — especially pruning — on this species.

(2) The tending of radiata pine, with its critical timing, was not widely understood before 1960; "catching up with the backlog" was a prevailing policy (*e.g.*, New Zealand Forest Service Annual Reports 1952, p. 15; 1958, p. 36; 1959, p. 30; 1961, p. 15; *et al.*).

(3) It seemed naturally more promising to work with a profitable species, but no analysis was made as to why it was more profitable.

Douglas fir continues to pay higher overall stumpages than radiata pine (with some exceptions) but as the silviculture it has received has been ideal for its end use, and that received by the present sawlog supplies of radiata pine has been nugatory, it is debatable that: ". . . the quality of the timber is so much better than that of radiata pine that much higher stumpages can be expected" (Spurr, 1961). This "better quality" is true of current supplies, but is doubtfully attributable to the future.

Some North American Pacific Coast prices and stumpages for Douglas fir and pine timber are given for comparative purposes in Tables 15 and 16. Relatively, the Canadian western pine resource is very limited and the figures are of less consequence than those from the U.S.A. Stumpages, of course, reflect costs of production as much as realizations and are less appropriate sources of comparison than timber prices. A further qualification is that North American prices vary frequently; but those shown in Tables 15 and 16 cover a representative range. The relative value of the two groups has been discussed (Reid, 1953): "The pines provide the cream of the forest crop with their even texture, ease of sawing, seasoning and machining — high qualities for finishing" and "I suggest that our *P. radiata* on managed forests could

TABLE 15: RELATIVE NORTH AMERICAN STUMPAGES

Year	United States[1] Douglas Fir	Ponderosa Pine	Sugar Pine	Southern Pine	British Columbia[2] Douglas Fir	Western Pines	All Species
1910–19	1.03	1.35	1.75	1.33	—	—	—
1920–29	1.20	1.80	2.17	1.79	—	—	—
1930–38	1.05	1.40	1.91	2.16	—	—	—
1940–49	4.09	3.77	4.25	5.61	—	—	—
1950–54	10.70	13.62	16.79	16.84	5.4	13.2	4.5
1955–59	15.57	12.05	14.92	17.20	5.5	13.1	4.2
1960–63	14.43	8.11	11.13	14.45	4.9	9.5	2.9

Stumpages are in pence sterling per cu. ft.

[1]U.S.D.A. 1964. Stumpages are for National Forests, and are averaged over 10 and 5 year periods; yearly fluctuations are considerable.
[2]British Columbian Forest Service, Annual Reports. Stumpages are as bid; lower stumpages apply to 'tree farm' licence areas.

TABLE 16: COMPARATIVE TIMBER PRICES OF DOUGLAS FIR AND PINE — WESTERN U.S.A.[1]

Prices in shillings sterling per 100 bd. ft.

Grade	*Size (in.)*	*Ponderosa Pine*	*Sugar Pine**	*Douglas Fir*
C and better	6×1	185.4	213.6	124.8
		184.4	198.5	118.5
	12×1	214.7	—	136.7
		210.8	—	142.0
D Select	6×1	116.2	141.2	99.8
		115.0	137.8	106.3
No. 1 Shop	$1\frac{1}{4}$	99.2	98.3	79.6
	thick	98.4	103.2	76.5
No. 1 Common	1 in.	96.5	—	—
		91.5	—	—
No. 2 Common	4×1	72.5	75.1	68.3[2]
		73.5	72.6	57.0
No. 3 Common	4×1	45.5	46.7	40.3*
		44.6	49.2	41.0*
Framing Timber —				
Std and better	$4\times1\frac{5}{8}$	47.9	—	54.1
		44.7	—	53.0
Std and better	Studs	43.0	—	43.8
		41.6	—	44.5
Utility	$4\times1\frac{5}{8}$	26.6*	—	32.9
		29.1*	—	32.4
Economy	$1\frac{5}{8}$	16.8	—	12.6
		19.3	—	10.9

[1]Western Wood Products Association, 1966A and 1966B.
[2]No. 1 and No. 2 Commons.
All prices are for dry timber; those for the pines include dressing. Prices are gross, f.o.b., for the last two weeks of December, 1965.
* Widths not specified.

possess the same advantages over Douglas fir . . . which western pines have in the U.S.A." and, further, "Douglas fir is, of course, a remarkable constructional timber, but the grades required for most construction need not be clears and prices for constructional timbers are always lower than for finishing". New Zealand-grown radiata pine and North American ponderosa pine (*Pinus ponderosa* Laws) have been considered elsewhere to be quite comparable (Vaughan, 1965). Historically, from about 1910 until as recently as 1955, the differentials in stumpage between sugar (*Pinus lambertina* Dougl.) and ponderosa pines and Douglas fir in the U.S.A. have markedly favoured the pines; since 1956, however, the stumpage/price relation has been reversed. The North American supply and market situation is referred to later, but the spectacular development of a structural veneer market, and increased demand for saw timber exports, together with an increasing shortage of accessible old growth log supply (Haley, 1963; Anon., 1963) are primarily responsible for the current differential. Timber prices, as against those for logs of pines and Douglas fir, still maintain a considerable differential in favour of pines for the high-quality board grades; Douglas fir maintains a price margin for the best framing grades.

The amount of Douglas fir used in the pulp industry in New Zealand is limited; only a very small resource is available to two of the integrated mills, while the third chips about one-third of its log intake of this species. This proportion corresponds with that utilized by the larger State mill as round produce, although the latter is, of course, much more profitable as stumpage. The growing diversion of sawmill residues to pulp mills in the Douglas fir regions of North America could be followed eventually by the large sawmills in New Zealand, but pines will be preferred to Douglas fir as a pulpwood resource (Reid, 1962). The trend to chip residues has been criticized in North America, where it was contended that, as timber is always more profitable than pulpwood chips, it would have been preferable to concentrate on innovation in sawmilling, rather than accept the volume of waste produced as a low value product (Guthrie and Armstrong, 1961).

THE NORTH AMERICAN RESOURCE

Any study of the relative profitability of Australasian forestry demands at least some assessment of the current and future North American supply. It has already been indicated that Australia is an important market for U.S. exports of Douglas fir, but of lesser significance in the substantially greater export trade of Canada. The persistence of the United States exports to Australia is interesting in view of its own position as the largest importer of Douglas fir timber, and the distinct market preference there for this species (Haley, 1963). The presence of representatives of the two largest U.S. timber companies, and of the British Columbia Lumber Manufacturers Association in Australia, and the recent extension of sales outlets on the Sydney market (Anon., 1965b) by one of the world's largest timber companies, indicate that North American sales will be a permanent feature of the Australian market. Some indication of the level of competition

is shown by Weyerhaeuser Company's 1964 timber production of 1,588 million bd. ft, 8% of which was exported, and over a third of whose exports went to Australia (Anon., 1965c).

The continued dominance of Douglas fir on the Australian timber market is more remarkable in view of the large increase in finishing quality lines of South-east Asian light hardwoods available since 1950 and the reorientation of Canadian framing sales efforts to hemlock (*Tsuga heterophylla* (Rev.) Sarg.), renamed "Canada pine" in 1962 (B.C.L.M.A., 1964). Both Canada and the United States have sought to broaden the basis of their timber exports, with decreasing reliance on European (particularly United Kingdom, Italian and West German) markets, which are subject to severe and increasing competition from the Soviet Union. One difficulty in analysing a given species or market is that it cannot be considered in isolation (Worrell, 1966) and this certainly applies to an internationally traded species such as Douglas fir; but these interrelated market influences are only acknowledged here.

The tempo of development in forest industry in North America is rapid, and while published information is usually of an excellent standard, the generalizations which follow are drawn from data constantly being modified. For example, resources are based on definitions of timber-sized trees of 11.0 in. d.b.h. in the U.S.A. and 9.0 in. in British Columbia, and changes in utilization standards may greatly alter projections. Comprehensive data are included in the references given, and the account which follows deals only with the major trends as they affect Australasia.

Old growth (over 160 years) Douglas fir is by far the most important timber sawn on the entire Pacific West Coast of North America, comprising over half the cut in 1952 (Guthrie and Armstrong, 1961). It has been estimated that only 1% of this cut in the Douglas fir region was then of pole timber (Guthrie & Armstrong, 1961); later figures, however, show that, in western Washington and Oregon, 15% of the cut is from young growth stands (Anon., 1963). In 1962, 16% of the United States Pacific Coast cut came from trees of 19 in. d.b.h. and under (Anon., 1965d).

In British Columbia, the shift in timber harvesting has been both from the coast to the inland areas, and to other species, rather than to the coastal young growth Douglas fir stands. The predominance of Douglas fir in the overall cut has been reduced from round 70% in 1940 to 35% in 1965 (British Columbia Forest Service annual reports). Simultaneously there has been a tendency for costs to rise, owing to smaller log size, increased freight and a reduction in grade outturn due to increased defect. Scaling defects ranging from 35 to 60% of gross volume have been recorded for inland Douglas fir (McIntosh, 1964). However, the net cost of production has not increased appreciably, as a result of increased efficiency (Guthrie and Armstrong, 1961). Hemlock now almost equals Douglas fir in overall timber production — 22 and 26.5%, respectively, in 1964 (B.C.F.S., 1964) and outproduces Douglas fir by over a third in the coastal region. The hemlock resource consists largely (84%) of old growth stands, whereas Douglas fir old growth now comprises only 32% of the total area of the species (McKee, 1959). Hemlock has always been a more important source of pulpwood, being favoured for sulphite pro-

TABLE 17: SOME UNITED STATES THINNING COSTS[1]

Place	Age	Volume per Acre[2] Extracted Thousand cu. ft	Total Yield of Operation Thousand cu. ft	Man-hour Production cu. ft	Topography	Extraction Method	Cost per cu. ft on Skids[3] (d.)
Hemlock[4]	50	0.66	33	33	Gentle	Horse	7.1
McCleary	55	0.5 to 1.0	161	48	Moderate	Tractor	6.8
Hood Canal	65	0.8	80	46	Gentle	Tractor	7.4
Big Creek	70	1.2	120	37	Easy	Horse & Tractor	8.0

[1]Worthington and Staebler 1961.
[2]Converted from board feet by a factor of 5.5.
[3]Cost in pence sterling; half of the miscellaneous costs apportioned to felling and extraction.
[4]Produce was 8 ft pulpwood from Hemlock, and both saw and pulp logs from the other areas. These were all natural stands and in Hemlock and McCleary, species sorting was required.

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Douglas fir is overwhelmingly the main species used in the west coast plywood industry, although quality standards and requirements have dropped sharply over the last decade. In plywood, as in timber, there has been a shift to other species; these comprised 9% of the softwood plywood produced in Canada in 1964, compared with 2% in 1960 (Haley, 1964). In the United States, southern pine plywood production is increasing rapidly, although Douglas fir still made up 87% of all the logs used in 1963 (U.S.D.A., 1964).

It is the Pacific coastal, as against the inland, regions of both Canada and the United States which supply the great majority of the export timber, and as the domestic market is being increasingly gained by the interior mills, interest in exports from the coastal areas intensifies (Guthrie and Armstrong, 1961). Overall grade outturns are difficult to obtain, but a recent survey of the United States timber industry showed a decline of clear-cutting grades; in the "Douglas fir region" of western Oregon and Washington, Douglas fir itself produced 62% and hemlock 17% of these grades (Anon., 1965e). Nationally, Douglas fir provided 18% and hemlock 4% of the current production of these higher grades; and it appears that high-grade hemlock will increase at the expense of Douglas fir (Anon., 1965e). Timber grade outturns were not mentioned in analyses of financial returns of British Columbian Douglas fir, although log grades were incorporated (Haley, 1963). Some actual grade results of young-growth Douglas fir from the United States showed, for the instance quoted, an excellent outturn of 31.9% Select Structural; 53.8% No. 1; 12.1% No. 2 and only 2.2% No. 3 for logs of 8 to 21 in. diameter (Worthington and Staebler, 1961). It is not known if such yields are characteristic; vagaries of spacing in the naturally regenerated young growth stands, which were more or less unmanaged at the time of their origin, will control the grade potential. No detailed figures on the extent of thinnings and utilization of young growth stands are available; thinning is currently assessed as being a marginal operation, and while techniques have recently been analysed (Worthington and Staebler, 1961; Willison, 1965) they do not include any methods new to Australasia. Costs are similar to those in New Zealand, but the volume extracted per acre is much less (Tables 13 and 17).

The United States yield tables have been revised several times (McArdle *et al.*, 1961) and the trends shown in them have been reported as agreeing with those of the best stocked permanent sample plots there (Williamson, 1963). Data for British Columbia are more limited, where yield tables for thinned stands depend partly on British and German results (Warrack, 1959). The main use of the yield tables appears to have been to estimate future resources, rather than as a current tool of management.

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The impression gained from North American literature is that the second growth cut currently provides less than 15% of the overall cut; but, if industry develops techniques for utilizing the resource at costs similar to today's, the volume available is sufficient to provide for a formidable timber production. The biggest gaps in the data are the future costs and methods of production of this material, its grades, and their acceptability on the market. Extensive second growth stands elsewhere in the U.S.A., particularly in the south and north-east, are now successfully marketed. As far as competition on the Australasian market is concerned, it should be noted that Canadian stumpages are low, and, although United States stumpages for national forests are higher, much of the potential export resource is owned by private companies. In the Douglas fir region of western Oregon and Washington, the four largest companies own 3.49 million acres, which is 13.7% of the commercial forest of the area (Mead, 1964). The Federal government, through several agencies, owns 51% of the standing timber on 38% of the forest in this area (Mead, *op. cit.*). The lower Canadian stumpage is equivalent to a price advantage of around 13 shillings per 100 bd. ft if other costs of production are equivalent.

It is not possible to decide whether Australia or New Zealand can produce from their exotic plantations at costs competitive with the very large North American second-growth resource. The advent of management into these stands in the decades to come will be a deciding factor as to the level of profitability of New Zealand-grown Douglas fir. The labour costs in the Pacific North-West are high, and the costs of thinnings to date have not been lower than in New Zealand. The tariff advantage of about 10d per cu. ft in favour of New Zealand, when the current tariff is phased out in eight years' time, will gradually become of greater importance as the cost of large dimension virgin stock will inevitably rise, owing to competition for a diminishing resource. It is, however, an adage of the stock exchange not to rely on tariffs for profitability. Freight to Sydney on packaged softwood from New Zealand was 25s 9d sterling per 100 bd. ft in 1965 and Canadian freight to Adelaide was given as 26s 8d in 1963; so there is a negligible freight advantage: these rates can fluctuate (Commonwealth of Australia, 1963).

In summary, the North American supply shows a sharp and increasing drain on the old-growth resources but, despite this, the price of exports to Australasia has increased little over the past decade. The quality of clearwood available from Douglas fir will decrease as utilization shifts to the extensive young growth resource; the extra cost of logging and sawing these smaller logs will be compensated to some extent by their more favourable location, particularly in Washington, for export. Replacement of Douglas fir by hemlock will increase, and the grade potential of this substitute is high. There appears to be little thinning, but a considerable potential for it, and although the sawmill industry is not ideally equipped to deal with a small-log supply, the growing pulp and paper industry may reduce the cost of integrated utilization. Overall, there is plenty of log volume available. The national trends, in any case, are less appropriate indications when the export industry is so actively an interest of very large and well organized private companies.

THE CURRENT AUSTRALASIAN MARKET

Imports of Douglas fir into New Zealand are now on a small scale; the true demand for these imports is difficult to assess as, in addition to the tariff, they are restricted by a stringent set of import controls necessitated by a perennial shortage of overseas exchange. Data on the grades imported are not available, but these are thought to include "'fairly large quantities of No. 2 clears brought in specifically for manufacture of joinery, shop fittings and ladders" (J. S. Reid, pers. comm.). The structural grades for such uses as purlins in industrial buildings, scaffold planks and other uses where strength and stability are required, can be supplied from the exotic Douglas fir stands at costs equivalent to current imports. High quality clears for internal joinery can be largely supplied, two or three decades hence, from pruned pines, and continuation of current programmes will effect this substitution. Grades for ladders and other specialized uses would be a logical outcome from small areas of pruned Douglas fir if autarchy is to dominate policy. New Zealand has ample supplies of good grades of framing timber available from its first rotation of Corsican and radiata pines (Fenton, 1960, 1966) and as these stands age the proportion of higher framing grades increases. The Douglas fir estate adds still further to these supplies. Domestically, however, this framing is almost always used in a green (unseasoned) condition.

The New Zealand domestic market is one on which the competitive strengths of Douglas fir and radiata pine can be examined to some extent. The small available volume of Douglas fir results in a limited scarcity value, as the bulk of the framing used, after a decade of promotion and persuasion, is of pine. Douglas fir has a superficial price premium of round 16 shillings sterling gross per 100 bd. ft for 4×2 in. as against 4×2 pine No. 1 Framing grade; for all practical purposes in building this premium reduces to 1s 6d to 3s 6d per 100 bd. ft, as the pine has to be preservative treated, while the Douglas fir is accepted untreated. The result, as far as the forest is concerned, is a higher net stumpage for Douglas fir. Both timbers are readily accepted, and the net margin of 1s 6d to 3s 6d reasonably represents the amount of consumer preference for Douglas fir.

The overall Australian timber grade requirements are also difficult to assess; data on grades imported, as presented to Tariff Board hearings, are given in Appendix 2. They are not very specific, but indicate that a quarter of the imports are mainly clear timber used for finishing lines, and the balance is of merchantable grades for framing. This pattern of imports contrasts with those of, for example, West Germany and the United Kingdom, where most of the imports are clears, or of grades suitable for joinery (Anon., 1965f). Hence, in Germany "freedom of knots is demanded wherever possible for all purposes" and leads naturally to a policy of pruning for the exotic Douglas fir (Hilf and Maisenbacher, 1962). This need not apply to substitution for the major use — construction — in Australia, but the available plantation softwoods should be pruned if high grades for joinery are required. The attitude to pruning in Australia has varied between States and over time; Queensland has maintained a consistent programme of pruning (of butt logs) and South Australia — with the most extensive current resources — by contrast, has maintained since 1938 a consistent policy of not pruning. Currently the four remaining states regard pruning as an integral part of their plantation silviculture and so, in the future, may have equivalent grades available to match imports of joinery grade Douglas fir. The equivalent cost of production is not known.

The value of imports in maintaining markets for wood until equivalent local supplies become available is considerable, and increase of timber prices, owing to tariffs, may increase substitution. This view has been urged by exporting interests when opposing tariff increases in Australia (Anon., 1964a *et al.*), and the form of the tariff bears hardest on these high grades. Log supply in North America is such that the clear grade potential of large flitches must decrease as the old growth stands decrease; high grades will still be available, but more probably in small-sized timber. In New Zealand the shortage of high-grade joinery timber for external uses has led to suspension of tariffs on western red cedar and redwood. The correct balance between a penal tariff and a fair degree of protection is debatable and, while protests are made in the United States against Canadian tariffs on Douglas fir timber (Anon., 1964b), a proposal that the United States should reduce its tariff against Canadian softwood plywood was vigorously protested (Anon., 1965g).

The limiting factor governing successful substitution of Douglas fir by exotic pine for framing in Australia will be neither the actual strength of the timber, nor the presence of knots, but the stability of the product under conditions of low equilibrium moisture content in the summer. Owing to absence of pruning, framing grades are regarded as the highest grades in South Australia and a study showed that logs smaller than 13.5 in. s.e.d. "are undesirable for scantling (framing) because of subsequent excessive spring, . . . that the juvenile core should be avoided and that scantling should be sawn as far from the pith as possible" (Lewis, 1965). Similar work confirms that "sawing out a square of 3 or 4 in. minimum dimension surrounding the pith" avoids most of the unstable material (Boyd, 1964). These conclusions agree with those of South African work in utilizing similar pines. Technically, final fellings from exotic radiata pine plantations would be suitable as a source of replacement of imported framing. Because of circumstances, however, this technically suitable framing has not had its acceptability tested on the market.

The overall cut of about 234 million bd. ft from Australian softwood plantations (year ending 30/6/65) was about half that of the New Zealand production of 472 million bd. ft (year ending 31/3/65); and Australian production of other softwoods is less than 100 million bd. ft per year. Overall Australian timber usage, on a *per capita* basis, is only of the order of 140 to 165 bd. ft compared with 280 in New Zealand. One result of this relatively low production has been far less difficulty in selling the exotic softwoods than in New Zealand, and marketing is still dependent on box uses for 40% of sales (Ladkin, 1965). Generally, the Australian exotic log supply has contained a high proportion of thinnings — small logs suitable only for boxmaking. Outlets for Dressing grades have been established, producing lines generally equivalent to the

top of New Zealand Merchantable grade (namely, reasonably tight surfaces, but allowing some cone-stem holes). Because of a modest overall cut, derived largely from small logs unsuitable for framing, and a relatively easy sale for box-board uses, Australian production of framing grades of radiata pine has been negligible. Even in the south-east of South Australia, said to be 10 to 15 years ahead of the rest of Australia, only 1.5 million bd. ft of radiata was used for framing in 1962 (Ladkin, *op. cit.*). Imports of New Zealand construction grade are also small — *i.e.*, two to four million bd. ft per year — despite the fact that half the New Zealand exotic cut is for framing. This is partly due to the traditional use of unseasoned framing within New Zealand, and partly due to its inability to compete with the current grades of imported North American Douglas fir.

Production of pine framing would also act against the sales of hardwoods, which are used unseasoned for framing and supply much of the forest revenue in states other than South Australia. The price premiums in favour of Douglas fir, in comparison with hardwood framing in the Sydney and Melbourne markets, were given as 1.6 and 52.8 shillings sterling per 100 bd. ft in 1963 and 9.2 and 56.8 shillings sterling per 100 bd. ft in 1960 (Commonwealth of Australia, 1963, 1960). The results of the relative effects of royalty and freight are discussed in Tariff Board reports (Commonwealth of Australia, *op. cit.*) where it was concluded that in Western Australia, Victoria and Tasmania unseasoned hardwood framing "has a decided price advantage over Douglas fir in their intrastate markets and little Douglas fir is used in home production in those States".

Currently, then, North American Douglas fir remains a major source of framing timber, and faces competition mainly from Australian indigenous hardwoods. It has sustained this position for at least four decades under both relatively low and high tariffs. This situation will be subject in the future to five major influences: two North American and three Australasian. The dual North American influences are the decline of the old growth resource, which supplies the large baulks currently favoured by Australian importers, together with efforts to divert consumption to the relatively more abundant old-growth hemlock resource and to young-growth Douglas fir. Competition will come from the New Zealand exotic Douglas fir, which will be able to compete with American young-growth material on equal terms, as far as quality is concerned, owing to the more intensive management of plantations. The ultimate tariff advantage should react in favour of the New Zealand produce. Australian and New Zealand grown radiata pine has yet to establish commercially what is possible technically — its suitability as acceptable framing in Australia. The exploitation of this market potential depends on a reasonably high level of production standards, on price, and on sustained sales promotion. It seems possible that this will be stronger from New Zealand than from the Australian states (excepting South Australia) because:

(1) There will be continued pressure to maintain sales of indigenous Australian hardwoods, owing to considerations of rural employment, to maintenance of revenues, and to established practice and equipment for converting this material.

(2) The generally large size of new (post-1950) exotic sawmills in New Zealand, well equipped to saw and season framing.

(3) The availability over the next decade of increasing quantities of larger and older trees, whose main outlet for profitable utilization is either as finger-jointed or as framing timber (Fenton, 1966). This pressure of supply, whose only alternative market is an export trade of logs, provides an urgent incentive that is lacking in Australia.

THE FUTURE OF DOUGLAS FIR IN AUSTRALASIAN AFFORESTATION

Examination of the current supply of timber in Australia leads to the conclusion that Douglas fir still commands a major market. The opinion of the Australian Tariff Board in 1960 "that Douglas fir imports met a demand which could not be adequately met from Australian sources" (Commonwealth of Australia, 1960) is reasonable. In future, however, use of correctly seasoned and preferably stress-graded radiata pine could replace Douglas fir as framing, while the pine is superior for finishing uses where strength is not important. The major need now is a knowledge of the relative cost of production of the alternatives, and this is the subject of current research. The true competitive position will ultimately depend on price, and such current advantages of Douglas fir as its availability in large sizes for profitable recutting for grade will decrease as large old-growth supplies decrease.

The North American material will still come from natural stands and bear the costs of stumpage and utilization only. However, United States Federal stumpages of round 14 pence per cu. ft are higher than the 5 to 8 pence per cu. ft paid for Australian hardwoods (Commonwealth of Australia, 1960, 1963) and are equal to the stumpages paid for indigenous softwoods in New Zealand.

On end-use considerations only, there is little need for Australia to plant Douglas fir, as equivalent timber is potentially available from radiata pine and the object of expanded afforestation is to replace imports. To do this by growing Douglas fir instead of radiata pine as an exotic would take from 20 to 30 years longer, and market preference for the species would have to be sustained by imports during this period to benefit from its current market reputation.

About two-thirds of Australian state plantations are of radiata pine, and the degree of biological risk involved by concentration on one species is debatable. Much of the remaining area is unsuitable for radiata pine (and Douglas fir), and in any case provides a considerable degree of diversification. Furthermore, no serious pathological outbreaks have affected well-sited radiata pine in Australia, although sustained productivity following successive monocultures is less certain. The maintenance of very large areas of indigenous hardwoods, albeit on extensive management with low rates of increment, present further considerable diversification. Quantifying the degree of risk, or even deciding what proportion of a given species should be grown, is impossible but it is feasible to calculate the cost of diversification if slower growing species are used to replace radiata pine on good sites. Apart from establishment on sites which present limitations for radiata pine, there is no compelling reason why afforestation of Douglas fir should be extended in Australia.

The proportion of radiata pine in New Zealand State forests is just under 50%, and about 10% is planted with Douglas fir. Moreover, the preponderance of radiata pine in private forests alters these proportions to about 60% radiata pine and 6½% Douglas fir in the million acres of exotic softwood forest. On present evidence it is improbable that indigenous production will be maintained for much more than 30 years. Pathological troubles have been more serious in New Zealand than in Australia, although quantitative assessments of their net effects are lacking. The well-established series of age classes of Douglas fir provides a good basis for future management, and this species has formidable merit in the low mortality of unthinned stands up to 45 to 50 years of age. This attribute favours its being planted on the extensive steep areas available for afforestation, which cannot be thinned economically with current techniques. The alternative of 20- to 25-year-old crops of radiata pine for pulpwood remains untried. Extension of the area under Douglas fir to between a fifth and a quarter of the exotic estate is suggested.

The disadvantages of further establishment of Douglas fir are the longer period before profitable thinnings can be made, when compared with radiata pine (35 instead of 20 years); and, more important, its more restricted range of end uses. Diversifying planting with this species involves a concurrent risk of diminishing market outlets. The superor versatility of radiata pine in utilization, and its formidable early increments, should continue to make this the premier species in New Zealand afforestation. Douglas fir is a valuable species, and extended future plantings are justified by considerations of biological diversification, its suitability for management in steep country, and its timber qualities.

It remains to assess the relative profitability of these two species.

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APPENDIX 1: DOUGLAS FIR — RADIATA PINE DEVELOPMENT KARIOI STATE FOREST, CENTRAL NORTH ISLAND

Year	*Douglas Fir*	*Radiata Pine*
	Altitude 2,200 ft; level site on old pasture.	
1927	Plots established.	
1941	A few scattered trees survive, but have made little progress and have no value as far as growth records are concerned.	
1965	Good form trees 77–88 ft high; 14–18 in. d.b.h.	Rough butt logs; reasonable form above. 106–115 ft high; 23–26 in. d.b.h.
	Altitude 2,400 ft; almost level site with slight undulations.	
1929	Plots established (both species on north side of *P. contorta* stands).	
1934	Plots are to be abandoned, a failure, trees badly frosted.	A large proportion of failures, trees suffering from *Phomopsis*.
1941	A few have survived, but are malformed and badly frosted.	41 ft high; a good average stocking with trees of a fair quality.
1943	Majority killed by frost and survivors still show severe frosting to 10 ft. Even slight deviations show marked improvement on survival and growth.	48 ft high.
1946		65 ft high; 12–16 in. d.b.h. The superiority of this stand is probably due to its being on a slight rise, reducing frost and *Phomopsis* damage.
1965	78–87 ft high, 17–23 in. d.b.h. A dense stand of good form trees overall; some butt logs rough.	110–124 ft high; 20–38 in. d.b.h. Normal form trees.
	Altitude 2,700 ft, on a slight slope to south, with a steeper slope beyond plot boundary giving good air drainage.	
1928	Plots established (radiata on south side of Douglas fir).	
1934	Well stocked and making good growth.	
1939		Survive in patches and much *Phomopsis* present.
1941	29 ft high, freedom from frost contrasts to other plots.	36 ft high. Poorly stocked and heavily malformed.
1947	43 ft high.	
1952	50–55 ft high.	
1965	87–97 ft high; 16–18 in. d.b.h. A good looking crop despite wide initial spacing.	100–110 ft high; 24–29 in. d.b.h. Poor overall survival, badly malformed butt and second logs.

(Earlier observations from local records, 1965 measurements by the writer.)

APPENDIX 2: AUSTRALIAN DOUGLAS FIR IMPORTS — GRADE AND END USES

New South Wales Imports

78% Merchantable grades, 22% Clears grade. Described as:
Merchantable — Suitable for structural purposes but not for dressing.
Selected merchantable — Better grade of merchantable, suitable for dressing.
No. 2 Clears — Good generally, but not entirely free from minor faults.
No. 1 Clears — Specially selected.

End Uses

Use	*Victoria* %	*South Australia* %
Industrial construction	55	26
Industrial uses	30	12
House building	15	62

(Based on a Forest and Timber Bureau Survey.)

It was stated that "a large proportion of Douglas fir (in New South Wales) was known to be used for home buildings . . . almost certainly more than in South Australia".

All data above from Commonwealth of Australia, 1960.

A later Tariff Board hearing (Commonealth of Australia, 1963) contained the following details:
New South Wales imports: "About 25% clear grades."
Victoria: About 10% clears in the last three years, and percentage is falling.
South Australia: About 5% clears.
Clear grades are also used for ladders, scaffolding planks.

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TABLE 1: VALUE OF FOREST PRODUCTS IMPORTS INTO AUSTRALIA
Value in NZ$ thousands, f.o.b. or c.d.v. basis.

Category	1960	1961	1962	1963	1964	1965	1966
	Years (year ending June 30)						
CLASS XVIA[1]							
Pulp, paper and paperboard	58,472	77,564	55,404	68,816	74,584	85,012	82,124
CLASS XVIB							
Paper manufactures	3,538	4,638	4,388	5,014	6,324	7,010	5,834
CLASS XIV							
Timber	32,148	36,348	24,416	27,620	32,912	38,040	35,206
Totals[2]	94,158	118,552	84,206	101,450	113,820	130,062	123,164

Totals from Successive Forestry and Timber Bureau Annual Reports 1961–65.

Annual Report Year	1960	1961	1962	1963	1964	1965
1965	—	123,652	88,516	106,316	118,562	135,476
1964	—	123,652	88,516	106,316	118,562	
1963	125,956	144,730	104,528	120,292		
1962	104,592	130,452	93,666			
1961	100,226	125,810				

[1] Customs classification used in Oversea Trade.
[2] Detailed data from Oversea Trade, 1963–64, 1965–66.
Total values are f.o.b. or c.d.v., whichever is the higher.

TABLE 2: MAJOR CATEGORIES OF RECENT AUSTRALIAN FOREST PRODUCTS IMPORTS
Value in NZ$ thousands, f.o.b. or c.d.v. basis.

Year to June 30	Pulp and paper[1]			Sawn timber			
	Pulp and waste paper	Newsprint	Total—all pulp, paper and paper manufactures	Douglas fir[2]	Radiata pine[2]	Malayan hardwood[3]	Total—all sawn timber[1]
1960	12,802	24,460	62,010	13,384	2,610	5,530	25,766
1961	16,788	29,404	82,202	13,596	1,940	7,892	29,594
1962	12,000	20,982	59,792	10,570	1,440	4,018	18,786
1963	17,484	24,178	73,832	10,814	1,380	5,108	21,182
1964	18,712	28,972	80,906	14,158	1,408	4,774	26,244
1965	22,888	31,318	92,022	12,764	1,866	8,216	29,322

[1] From summary Table 11 in Oversea Trade 1963–64; 1964–65.
[2] Specific figures from Oversea Trade 1959–60 to 1964–65, inclusive.
[3] Includes other hardwoods up to 1963; after that Malayan hardwood is specified separately.

of this, or $NZ120 million on a c.i.f. (cost, insurance and freight paid) basis (Camm, 1967). The Australian statistical data show variation — some of which is included in Table 1. Major categories of Australian forest products imports are shown in Table 2.

It should be noted that Australian trade statistics show values assessed for customs purposes, and are not necessarily the amounts of money paid for the commodities f.o.b. (free on board ship at export port). The c.d.v. (country-of-origin domestic equivalent value) is used if it is higher than the f.o.b. value. Hence New Zealand newsprint values, for example, for 1962–65, can be calculated as round $NZ132 per ton, whereas in fact they were $NZ115 f.o.b. A preferable basis to use would be c.i.f. (cost, insurance and freight paid), which would be about $NZ8 per ton less than the c.d.v. value (G. Yska, pers. comm.).

By world standards, both countries maintain high tariffs on most processed forest products (FAO, 1964; 1966).

TABLE 3: AUSTRALIAN PRODUCTION AND CONSUMPTION OF SAWTIMBER, PULP AND PAPER—ROUNDWOOD EQUIVALENT[1]

	Category							
	Sawtimber				*Pulp and Paper*			
	Production		*Consumption*		*Production*		*Consumption*	
Year	*Vol.*[2]	*%*[3]	*Vol.*[2]	*%*[4]	*Vol.*[2]	*%*[3]	*Vol.*[2]	*%*[4]
30/6								
1951	235	81.7	291	76.9	13	4.7	45	11.9
1952	264	81.8	328	74.5	14	4.4	61	13.9
1953	257	78.7	268	75.1	18	5.6	37	10.3
1954	269	79.4	303	73.8	19	5.6	55	13.5
1955	278	78.9	330	71.9	25	7.0	74	16.1
1956	282	76.7	328	71.1	29	7.9	70	15.3
1957	275	74.7	320	69.9	31	8.5	72	15.7
1958	267	74.3	311	69.8	30	8.3	70	15.6
1959	281	75.4	323	69.6	32	8.5	76	16.5
1960	292	74.5	344	67.9	32	8.2	89	17.5
1961	280	73.9	335	65.1	35	9.2	107	20.8
1962	233	70.5	274	64.2	32	9.7	82	19.2
1963	277	73.5	320	65.2	41	10.9[5]	104	21.2
1964	289	72.7	341	65.1	45	11.3	108	20.6
1965	292	72.0	349	63.6	52	12.8	122	22.4
2000[6]			750	58.0			483	37.0

[1] *Source:* Wilson, 1963; *For. Timb. Bur. Ann. Rep. 1965.*
[2] Million cu. ft.
[3] Percentage of total annual roundwood production.
[4] Percentage of total annunal roundwood consumption.
[5] Includes particle board.
[6] Forecast Hanson, 1962; sawtimber includes sleepers which comprise about five per cent. of current production.

TABLE 4: AUSTRALIAN FOREST PRODUCT IMPORTS, 1965–66
Values in NZ$ thousands f.o.b. or c.d.v. basis.

Category	*Total imports* *Value*	*%*[1,3]	*New Zealand component* *Value*	*%*[2]
TIMBER				
Douglas fir	13,488	11	144	1
Radiata pine	1,564	1	1,564	100
Malayan hardwoods	4,876	4	—	—
All timber[3]	25,620	21	1,775	7
PULP				
Unbleached sulphate	6,880	5½	4,682	68
Bleached sulphate	5,616		54	1
Unbleached sulphite	1,824		28	1
Bleached sulphite	4,500			
All pulp[3]	21,000	17	5,032	24
PAPER				
Newsprint	30,144	24	14,524	48
Impregnated and coated—not writing	9,680		—	—
Uncoated printing and writing	6,954		—	—
Kraft	938		—	—
All paper[3]	61,125	50	14,687	24
PAPER MANUFACTURES	5,834	5	109	
TOTAL FOREST PRODUCTS IMPORTS[3]	123,176		21,628	17½

Source: Oversea Trade 1965–66.
[1] Percentage of imports of Australian forest products.
[2] Percentage of category originating from New Zealand.
[3] Totals include other categories not given in detail here.

THE AUSTRALIAN MARKET

Detailed figures of Australian forest production and consumption are available (Wilson, 1963; *et al.*) and summarized figures for sawtimber and pulpwood only are given in Table 3. They show a relative decrease in the production and consumption of sawtimber, and a relative rise in the comparable figures for pulpwood since 1951. Sawntimber consumption (as roundwood equivalents) is about three times that of pulp and paper.

Geographically the Australian market for New Zealand timber exports is the south-eastern coastal fringe from Melbourne to Newcastle and, more problematically, Adelaide. Centres outside these areas can maintain a local freight advantage that would make any large scale imports unlikely on present costs. This estimate of the market is also that of New South Wales authorities: "The market [in N.S.W.] is Sydney, Newcastle and Wollongong and outside these areas there is virtual regional self-sufficiency" (Henry, 1965). Market forecasts are subject to great variation, conjecture being increased by the uncertainty of population projections beyond 1975. If present trends continue the population of Sydney and environs will be 6 to 6.6 million, and Melbourne 5 to 5.6 million by A.D. 2000 (Borrie and Spencer, 1964).

Currently Australian (and New Zealand) forest products imports — but not consumption — are dominated by pulp and paper, which comprise two-thirds of the value of imports. There are over 140 Customs categories for paper imports, and numerous commercial grades again within these. The claim made in successive Forestry and Timber Bureau annual reports that "almost all these products could be produced efficiently and cheaply in Australia" is an ambitious one. Major categories of Australian imports, and the New Zealand contribution, are given in Table 4. The greatest values of individual items imported are for newsprint, sulphate pulp and Douglas fir timber.

Several recent consumption forecasts for Australia have been made for the period 1975–2000 (Rodger, 1959; Hanson, 1959; Hanson, 1962; Turnbull, 1959). "All these forecasts are undoubtedly questionable on the grounds of the accuracy of the data on which they are based" (McGrath, 1965), but all found a large deficit of supply for future consumption. Demand estimates for most countries show a greater rise for pulp and paper products than for sawtimber, but the latter is estimated to still comprise more than half the total log supply in A.D. 2000 in Australia (Hanson, 1962) and New Zealand (Grainger, 1961), as well as in the United States (U.S. For. Serv., 1965).

The future Australian market for pulp and paper products has been assessed by projecting consumption trends for the last decade, and by comparing Australian and United States trends (Hanson, 1962). The *per capita* figures projected for A.D. 2000 are 230, 100, 75, and 65 lb for paper board, newsprint, printing/writing, and other paper, respectively (Hanson, *op cit.*). The Australian Forestry Council has apparently adopted Hanson's forecasts (McGrath, 1965), which require an increase in softwood afforestation to 75,000 acres annually.

"The increased consumption of sawn products [from 180 to 200 bd. ft per capita per year] is probably the most debatable of the estimates [of Hanson] as many forecasters think it will decrease. . . . Ritchie considers a more realistic figures to be 140 bd. ft." (Henry, 1965). The timber consumption in U.S.A. in 1962 was 200 bd. ft *per capita* and this is now projected to fall to 165 bd. ft in A.D. 2000, despite a reasonable surplus in overall wood availability over demand there (U.S. For. Serv., 1965). The deficiencies of anticipated total saw- and pulp-log supply in Australia would require the equivalent of about 4.6 million acres of softwood forest producing 200 cu. ft per acre m.a.i. if sawnwood consumption is 200 bd. ft *per capita* and population is 22.4 million by A.D. 2000 (McGrath, 1965). The actual area necessary will depend on log sizes, the increments of both exotic softwood and native hardwood forests, the degree of utilization of wood waste, as well as population and demand. Considerable uncertainty is inevitable for such projections. The difference of 60 bd. ft *per capita* for sawtimber consumption is of major importance, as an additional 1.1 million acres might be planted by A.D. 2000 if the higher forecast of 200 bd. ft *per capita* is adopted as the basis of afforestation. The increased *per capita* consumption of sawtimber forecast is contrary to the trend anticipated in other industrialized countries; it could presumably be justified in Australia by the absence hitherto of sufficient domestic supplies. The impact of other developing

Australian industries may be felt quickly; sales of aluminium, for example, are anticipated to be made primarily in the construction industry, which is the major user of timber. There is a considerable chance that the future Australian market will be oversupplied domestically by A.D. 2000, at least in terms of roundwood availability.

The extent to which Australian plantations can replace timber imports within the next 30 years — that is, before much material from the current expanded afforestation programme becomes available — is problematical. Forecasts take only indirect cognizance of timber grade as data are considered unreliable (Hanson, 1962) and emphasis is on the size of logs and timber required. In considering silvicultural aspects of exotic plantations in Australia ". . . the whole silvicultural problem is going to be thinning . . ." (Jacobs, 1962); and in reporting whether Australia could grow logs that would be suitable for future requirements ". . . the key problem . . . is the size question in the end-use of sawn wood . . ." (Jacobs, 1963). Hanson (1962) states ". . . the figures of consumption of sawn timber (in Australia) are available only in total and not separately with any degree of reliability into constructional . . . finishing . . . case timber etc.". An official survey evidently showed that ". . . more than 90 per cent of the sawn wood used in Australia; other than . . . sleepers, is finally used in cross sections of 16 sq. in. . . . or less" (Jacobs, 1963). By contrast, New Zealand forecasts now include categories of sawn timber (Williams, 1965).

Elsewhere there is recognition of grade problems, and the probability of declining grades has been anticipated (Turnbull, 1959; Bryant, 1962). Bryant (1962) instanced the increasing production of fibre and particle-boards as indications of future trends; details of New Zealand and Australian production are given in Table 5. Australian *per capita* production of both products is double those in New Zealand, and it is feasible to ascribe this to the better grades of (indigenous) timber, and the generally greater availability of all sawn timber in New Zealand. Bryant, acknowledging that he was not concerned with profit margins, continued: "If we can grow the crop rapidly, disintegrate it, cheaply bind it together again in new form then why should we worry to grow wide boards . . ."; and he concluded that Australia's best export prospects were for wood-based sheet materials and for pulp products.

The defects caused by dead branches and their effects on board grades have had a more limited effect in Australia than in New Zealand to date as:

Branch size is smaller, and green crowns appear to be deeper.

The majority of logs sawn are from thinnings, rather than clear fellings, and so represent the smaller tree sizes.

A relatively good local market is available for the limited sawn softwood production (Entrican, 1957); a third of the timber sawn is still going into box making (Ladkin, 1965).

There are lower and probably more realistic standards of pine timber required for flooring, which accept some cone-holes and pith.

Queensland is the only State in which extensive pruning was an integral part of the silviculture of the original (up to about

TABLE 5: FIBRE- AND PARTICLE-BOARD PRODUCTION IN AUSTRALASIA

Year[3]	Fibre-board[1] Australia Hard Million sq. ft	Fibre-board[1] Australia Hard Thousand tons[4]	Fibre-board[1] Australia Soft Million sq. ft	Fibre-board[1] Australia Soft Thousand tons[5]	Fibre-board[1] New Zealand Hard and soft Thousand tons[4]	Particle-board[2] Australia Million sq. ft[4]	Particle-board[2] New Zealand Million sq. ft[5]
1959	261	107	24	7	23	0.4	1.2
1960	285	117	23	7	25	0.9	1.0
1961	280	115	23	7	25	6.2	1.9
1962	259	106	20	6	32	11.1	1.9
1963	300	123	21	6	27	19.1	3.3
1964	357	147	21	6	29	32.6	3.3
1965	383	157	21	6	32	51.2	6.4

[1] Statistics are recorded on a different basis in each country. Australian figures have been converted to tons on a basis of $^{3}/_{16}$ in. thickness and a density of 59 lb/cu. ft for hard fibre-board, and ½ in. and 16 lb/cu. ft for soft fibre-board.
[2] Australian production all thicknesses; New Zealand ½ in. basis.
[3] Year ending 30/6 in Australia, 31/3 in New Zealand.
[4] *For. Timb. Bur. Ann. Reps. 1962, 1965.*
[5] Yska, 1967; *N.Z. For. Serv. Ann. Reps. 1965, 1966.*

1950) plantations, and the 100,000 or so acres pruned are of slash and hoop pines, which are slow growing by New Zealand standards. Details of the extent of pruning in the other Australian States are summarized elsewhere (Fenton, *et al.*, 1963); current plans in all States except South Australia now include pruning. The South Australian emphasis on framing timber as the highest end-use of timber is logical for a forest estate that is predominantly unpruned.

EXPORTS OF NEW ZEALAND FOREST PRODUCE

Current exports include the sale of logs to Japan (had machine capacity been available, the log volumes exported in 1964 and 1965 could have produced 100,000 tons of newsprint annually). There is also a small timber export trade with the Pacific Islands, mainly of Douglas fir, and of box-shooks. Exports of baulk sizes (10 × 10 in. and greater cross-section) of sawn radiata pine began in 1967. Prior to 1966, Australia was overwhelmingly the main recipient of unbleached sulphate pulp exports, but exports to Japan began in 1965, and increased in 1966 when exports to Australia dropped to 79% of the total exports of this commodity. Otherwise, sales of New Zealand forest produce exports are concentrated in Australia, which, if logs are excluded, took 95% of all forest product exports in 1964 and 1965. The Australian forest products industry remains about twice the size of New Zealand's (Table 6) in all categories apart from sawn softwood, newsprint and sulphate-pulp; these three commodities are, however, the largest individual items of forest products imported by Australia. Details of the value and volume of recent exports are given in Tables 7 and 8; volumes of timber exported to Australia alone are given in Table 9.

Exports are favoured by a ". . . very significant freight advantage . . . to New Zealand. This . . . is given by the shipping companies, and not as a result of agreement between governments" (Hanson, 1963). The overall trade imbalance between Australia and New Zealand is, however, so great that ships are only half full on their passage to Australia. Details for the last three years are given in Table 10; the ships entering Australia from New Zealand have among the highest proportion of ballast of those from any country, and the converse is true of Australian-New Zealand ships (Anon., 1966). The freight rates shown by Hanson for Australian timber include surcharges of 20 to 25c NZ per 100 bd. ft for the ports of Coff's Harbour and Brisbane (but which do not apply elsewhere) and this surcharge also inflates the differences. The softwood timber is half the weight of most of the hardwoods, which contributes to a minor degree to the difference in cost of shipping. The shipping company primarily concerned is a New Zealand registered subsidiary of an English company. New Zealand has a further freight advantage as the softwood timber exports are invariably packaged, against the unbundled Australian timbers.

Over the last decade New Zealand exports show a decreasing proportion of pulp as more is used domestically, and a jump in newsprint exports which followed installation of a second newsprint machine in 1963. Actual prices in pulp have risen by 15% while the more important newsprint price has fallen by 25% over the last decade. These changes largely reflect world price levels

TABLE 6: SCALE OF FOREST PRODUCTION IN AUSTRALASIA

Product	*New Zealand*[1] 1962	1963	1964	1965	1966	*Australia*[1] 1962	1963	1964	1965
SAWNTIMBER[2]									
Hardwoods	36	27	28	29	33	957	985	1,048	1,079
Softwoods	657	616	638	707	724	293	328	337	326
PLYWOOD[3]	53 approx. 50 to 55 per annum					203	195	216	199
PULP[4]	276	306	369	396	411	220	259	286	315
PAPER[4]									
Newsprint	92	114	168	184	196	90	90	92	93
Paperboard	41 }	109	128	127	153	208	242	258	283
Other paper	56 }					214	256	298	344
TOTAL ROUNDWOOD EQUIVALENT[5]									
Produced	175	164	182	201	207	355	376	398	406
Consumed						447	490	524	548

Sources: Yska, 1967: *N.Z. For. Serv. Ann. Reps. 1963–1966; For. & Timb. Bur. Ann. Reps. 1962–65.* Where the figures vary in successive reports, the latest issued are used above.

[1] Australian year ending June 30, New Zealand year ending March 31.
[2] Million bd. ft.
[3] Million sq. ft, $^{3}/_{16}$ basis; the New Zealand volumes are estimated from the equivalent round log volume utilized.
[4] Thousand tons.
[5] Million cu. ft.

TABLE 7: NEW ZEALAND EXPORTS OF FOREST PRODUCTS BY ROUND-PRODUCE EQUIVALENT VOLUME AND VALUE

Year	*Logs & poles* *R.P.*[1]	*Val.*[2]	*Sawnwood* *R.P.*[1]	*Val.*[2]	*Chemical Pulp* *R.P.*[1]	*Val.*[2]	*Newsprint* *R.P.*[1]	*Val.*[2]	*Total*[3] *R.P.*[1]	*Val.*[2]
1957			5.0	36	13.0	40	4.3	101	23.0	52
1958	1.2	22	7.2	36	13.1	42	5.0	105	27.1	52
1959	5.0	21	9.3	36	14.6	40	5.2	105	35.0	47
1960	4.3	26	8.7	35	13.3	42	5.9	104	33.3	51
1961	9.2	25	6.4	32	12.1	42	5.5	98	33.5	45
1962	9.3	27	6.7	32	13.3	43	5.0	92	34.5	44
1963	9.7	26	6.4	33	12.0	43	12.7	92	41.0	53
1964	12.6	26	7.7	32	12.5	45	13.5	89	46.5	51
1965	15.6	26	7.4	34	10.2	46	13.2	87	46.6	49

[1] R.P.=round produce equivalent in million cu. ft.
[2] Val.=value in cents per cu. ft of round produce equivalent.
[3] Includes small quantities of other products not specified above.

TABLE 8: TOTAL VALUES OF NEW ZEALAND FOREST PRODUCE EXPORTS

Values in $NZ million f.o.b.

Year	*Logs & poles* *Value*	*%*	*Sawnwood* *Value*	*%*	*Chemical pulp* *Value*	*%*	*Newsprint* *Value*	*%*	*Total value*[1]
1957			1.8	15	5.2	44	4.4	36	12.0
1958	0.2	2	2.6	18	5.4	38	5.2	37	14.2
1959	1.0	6	3.4	20	5.8	35	5.4	33	16.4
1960	1.2	7	3.0	18	5.6	33	6.2	36	17.0
1961	2.4	15	2.0	14	5.0	33	5.4	36	15.0
1962	2.6	16	2.2	14	5.6	37	4.6	39	15.2
1963	2.6	12	2.0	10	5.2	23	11.6	54	21.4
1964	3.2	14	2.4	10	5.6	24	12.0	51	23.6
1965	4.0	17	2.6	11	4.6	20	11.4	50	23.0

[1] Includes minor products not specified above.
Source: Yska, 1967.

TABLE 9: NEW ZEALAND SAWNWOOD EXPORTS TO AUSTRALIA

Year	*Total sawnwood exported*[1] *Volume Million bd. ft*	*Value $ thousands*	*%*[3]	*Radiata pine exported*[2] *Volume Million bd. ft*	*% of sawnwood exports to Australia*
1950	14.0	680	94	8.6	61
1951	20.2	1,372	94	17.0	84
1952	16.1	1,132	95	8.3	52
1953	17.3	974	84	15.0	87
1954	30.9	1,588	93	30.7	99
1955	39.6	2,192	93	37.3	94
1956	32.5	1,894	94	31.7	97
1957	28.5	1,642	95	27.3	96
1958	35.3	2,114	88	33.7	94
1959	46.9	2,890	92	39.2	84
1960	44.7	2,738	94	40.7	91
1961	28.7	1,698	89	24.5	85
1962	28.6	1,680	87	25.0	87
1963	27.6	1,609	85	22.1	94
1964	27.6	1,634	83	27.3	88
1965[4]	35.8	2,160	85	33.5	93
1966[4]	28.9	1,786	88	26.8	93

[1] Yska, 1967.
[2] P. Whitlock, pers. comm.
[3] Percentage of volume of timber exported to all countries.
[4] Figures for 1965 and 1966 are provisional.

TABLE 10: AUSTRALIA-NEW ZEALAND SHIPPING—BALLAST[1]

Year	*Australia-New Zealand* *Entering Australia*	*Leaving Australia*	*Australia—all countries* *Entering Australia*	*Leaving Australia*[2]
1961–62	54	9	25	30
1962–63	52	7	20	33
1963–64	50	7	25	29

[1] Percentage of total shipping tons in ballast.
[2] Figures are increased by empty oil-tankers returning to Arabian ports.
Source: Anon., 1966.

but the expectation that, in contrast to New Zealand's pastoral exports, the volume of pulp and paper exports would be too small to affect world prices (Larsen, 1960) has been disproved by events, at least as far as the Australian market is concerned. A cut in the price of Canadian newsprint was "deplored locally" and Schmitt of Tasman Pulp and Paper Co. was quoted as saying "the Canadian action was clearly intended to damage the position of Australian and New Zealand mills and it was suggested that further expansion in this area may be discouraged by the price drop" (Anon., 1965a).

An argument in favour of integration was: ". . . often prices of the various end products do not move together, and . . . by shifting emphasis in production and in the use of raw materials a significant improvement in financial returns and stability is possible" (Entrican, 1950). The paper (whether newsprint or kraft) side of a large integrated plant is normally run as close to full capacity as possible, the flexibility being mainly between the sawmills and the chemical pulp plants. The export values of New Zealand chemical pulp have increased, while those of newsprint have decreased from 1957 to 1965 (Table 7); in 1967 newsprint production fell slightly.

TABLE 11: EXPORTS OF KILN-DRIED TIMBER FROM NEW ZEALAND TO AUSTRALIA

Year	*Volume of all kiln-dried timber exports Thousand bd. ft*	*Exports of kiln-dried volume Thousand bd. ft*	*Construction timber % of total Timber exports*
1957	5,577	928	3.6
1958	8,233	1,466	4.2
1959	13,196	5,857	14.7
1960	9,342	1,894	4.8
1961	5.056	629	2.5
1962	4,443	270	0.9
1963	4,041	414	1.6
1964	3,668	503	2.2

Source: G. Yska, pers. comm.

Sawn timber exports since 1950 have been predominantly of radiata pine, for which Australia was virtually the only market. (The differences between total sawn timber exports and total radiata pine exports are due to box-shooks and to Douglas fir sales). In 1954, when the integrated mills began cutting, exports rose to 13.2% of the total New Zealand radiata pine cut, but have not reached this level since. Export figures show a fairly steady proportion — about 10% — of Factory grade, an increasing domination of sales by Box grade, and a short and passing contribution from Construction (Framing) grade (Tables 11 and 12). Expectations of results from the integrated and other big mills were ambivalent. Low grades were expected from the untended stands (Entrican, 1950), but high volumes of timber exports were still anticipated — 60 out of the 70 million bd. ft of the production planned for the Murupara (Tasman) mill were to be exported (Entrican, *op. cit.*), as it was hoped that mill integration would reduce the proportion of low grade timber. Typical expectations, at a time of sawn timber shortage, were: ". . . exotic forests must be systematically developed to yield 500 million bd. ft of sawn timber annually for domestic consumption and up to 150 million for export within about 15 years [viz. 1964], (N.Z. For. Serv., 1949); ". . . 60 million bd. ft will be exported annually [from the Tasman Pulp and Paper Co. Mill]", (N.Z. For. Serv., 1952). Both the State-inspired Murupara scheme, and the utilization based on private forests included large sawmills in the integrated plants.

By 1955 doubts had appeared: ". . . New Zealand has barely touched the market for higher grade . . . and . . . has done little to get footholds in these markets" (N.Z. For. Serv., 1955). In 1960 the absence of tending was being blamed for the "insignificant proportion of clear and defect-rare grades" produced, whereby only 50 million bd. ft of timber were exported (Entrican, 1960). Realization came: "When the Kawerau [Tasman] mill started a decade ago the N.Z.F.S. predicted that we would sell 150 million bd. ft of sawn timber annually to Australia . . . yet despite intensive promotion there has been no significant increase in the last decade . . ." (Larsen, 1965). And "The timber side has been a relatively weak point for Tasman for most of its history and one can wonder if the directors would again invest the large amounts . . . now tied up in timber production . . . if they had to do it again . . ." (Sturman, 1966). The case argued for integration (Entrican, 1950, 1957), apart from the versatility in marketing, was based on microwood technology, and although indisputable, largely ignored the branches. The pattern of branch-defects within the tree is such that the only practical method of obtaining finishing grade boards is by recutting and reassembly. The growing incidence of defects with increasing age of the stands (Fenton, 1967a) will continue to depress production of finishing board grades and integration cannot reduce these by log sorting (apart from Factory grade). Current grades of exports are given in Table 12.

The fundamental problem has been the inability to appreciate the interactions between age, tree defects and timber quality in plantations, which lead to the groundless expectation that older stands will produce better grades of boards. The anticipation that ". . . the long rotations of 50 years or more . . . will then yield a significant proportion not only of clear and defect-rare grades

TABLE 12: GRADES OF RADIATA PINE EXPORTS TO AUSTRALIA

Year	Grades in percentages of timber volume exported: Factory	No. 1	No. 2	No. 3 (Box)	Construction	Percentages: of N.Z. radiata Cut[1]	of Aust. softwoods Imports	of Aust. plantation Softwood production[2]
1955[3]	6.4	6.6	19.8	67.0	0.2	13.2	11.7	25.8
1956	7.1	6.0	16.1	67.5	3.3	10.6	13.4	21.6
1957	9.7	6.5	8.7	71.5	3.6	10.0	12.0	19.3
1958	11.5	6.0	10.8	67.5	4.2	12.6	13.0	20.1
1959[4]	10.1	5.8	8.2	61.2	14.7	13.0	16.3	17.9
1960	9.8	5.1	9.4	70.9	4.8	12.2	16.4	20.6
1961	9.2	4.1	6.9	77.3	2.5	6.8	12.4	18.8
1962[5]	9.1	2.1	7.5	80.4	0.9	6.7	11.5	13.5
1963	10.7	1.5	6.4	79.8	1.6	6.7	10.5	11.8[7]
1964[6]	8.5	1.0	6.6	81.6	2.2	8.4	9.5	11.7
1965[6]	9.5	2.0	6.6	80.7	1.2	6.0	11.7	N.A.

No. 1 Export grade is equivalent to New Zealand Dressing grade.
No. 2 Export grade is equivalent to New Zealand Merchantable grade.
No. 3 Export grade is equivalent to New Zealand Box grade.
Construction grade is equivalent to New Zealand No. One Framing grade with some additional qualities.
N.Z. For. Serv. Ann. Rep. 1955–1966; [2] Basic data from Wilson, 1963; [3] *N.Z. For. Serv. Ann. Rep. 1959.* [4] *N.Z. For. Serv. Ann. Rep. 1961;* [5] G. Yska, pers. comm.; [6] G. Yska, pers. comm.; [7] *For. Timb. Bur. Ann. Reps. 1963–1965.*

but of heartwood of good durability and excellent dimensional stability" (Entrican, 1960) is wrong with regard to the board grades (Fenton, 1967a) while the characteristic of durability — once of critical importance — is now technically almost unimportant owing to the advent of a wide-spread preservation industry. The only significant yields of tight-knot finishing grades of boards that can possibly be produced from radiata pine are from young stands about 25 years old; the alternative source of finishing quality boards is of clears from pruned stands. The lack of comprehension of the silvicultural characteristics of plantation-grown timber led to the assumption — now proven to be too optimistic — of a current export trade of 100 to 150 million bd. ft annually.

The timber potential is quite otherwise for framing — or construction — timber; older stands will produce an increasing proportion of better grades (Fenton, 1967a). This potential supply has been recognized (N.Z. For. Serv., 1955; Ward, 1957), and the quantity of kiln-dried Construction grade (virtually equivalent to the No. 1 Framing grade of N.Z.S.S. 169) sold to Australia is shown in Table 11. Sales rose quite sharply when supplies of Douglas fir from North America were restricted by a strike, but fell directly these supplies were available again. The marketing opportunity will recur more gradually as Canadian supplies of old-growth Douglas fir change to hemlock, and to second-growth Douglas fir (Fenton, 1967b). Construction (or Framing) grade is one of the only two reasonably good grades available in quantity from first rotation New Zealand stands; the other grade is Factory. Copious supplies of low grade box timber are available. The low proportion of the total export volume represented by Construction grades (Table 11, third column) indicates that the sales effort is inadequate. (These grades are potentially available in larger quantity, and are a reasonable substitute for equivalent North American imports.) Although "Industry is confident that kiln-drying down to 12 per cent and elimination of pith from overseas framing will result in satisfactory framing being available for use in Australia" (Ward, 1957) sales have been poor to date. The other major timber grade available in increasing quantities from the first rotation stands is Factory grade, for the production of short clear cuttings; production can be greatly increased by correct log sorting. Grade study results (Fenton, 1967a; Fenton and Familton, 1961) show more is available than mill outturns suggest. The increasing proportion of wides (10 and 12 × 1 in.) of Factory grade from untended or belatedly pruned stands is a potential source of exports which is under-utilized in current trade.

THE FREE TRADE AGREEMENT

The F.T.A. is the latest in a series of trans-Tasman deals; the main object appears to be, in a broad sense, defensive (Robinson, 1965; Mason, 1966). The view ". . . that the F.T.A. is surrounded by too many escape clauses and does not include very many important products in the 60% of trade it covers. But most accept it as a start and will be judging the treatment of forest products by Australia as a crucial test case, an indication of how serious Australia really is about closer trade relations" (Lipski, 1965) stresses the critical role of the forest products trade as a touchstone of the worth of the Agreement.

The F.T.A., as it stands now, is an extremely limited agreement and its only important points can be summarized:

Little new trade is liberalized.

The only exception of any importance is kraft paper, which is a heavily protected product in both countries.

The only tariff which remained on rough-sawn timber was that imposed on New Zealand Douglas fir as recently as 1963. After considerable pressure, it was abolished in September, 1967.

New Zealand quantitative import controls have been lifted from imports of Australian timber.

Mutual planning is proposed under the F.T.A. (Travers, 1967) and could undoubtedly avoid, in theory, direct clashes in export products; a genuine integration of Australasian forestry industry could be a benefit from the F.T.A. However, any knowledge of the degree of competition within the Australian States themselves shows how unlikely an overall forest utilization plan would be. This is exemplified by the divergent policies followed by the various State services. These differences of policy, *e.g.*, the lesser emphasis on radiata pine hitherto in Victoria, compared with New South Wales; early adoption of intensive pruning in Queensland and its rejection in South Australia; acceptance of Douglas fir for a part in afforestation in New South Wales and its virtual exclusion in Victoria, Tasmania and the A.C.T.; persistence with afforestation with native hoop pine in Queensland, but not in New South Wales, are not due to environmental differences. There are heterogeneous systems of log and of stand top height measurement, still in use in the various States.

A further barrier to international planning is that utilization is largely the preserve of private companies, and the desires of national planners are remote criteria unless considerable coercion is employed. "We are likely to find existing producers resisting threatened encroachment on their preserves by new entrants, not only by price competition, but also by various forms of pressure on customers and suppliers, as well as on government, designed to frustrate the plans of the potential competitors. . . . These are likely to be particularly important in forest products. . . . Much as they might like to avoid the difficult and politically delicate problems involved, it would seem to me that government cannot avoid playing a very positive role in planning. . . ." (Holmes, 1967).

As a complex illustration, policies in all but one of the Australian States, and in New Zealand, call for pruning of plantations. Up to 15,000 acres are butt-log pruned annually. The object of this work is to produce a clearwood sheath of up to eight inches. At the same time, inadequate improvements have been made to the low standards of New Zealand sawmills in cutting defect-rare indigenous species, so that much clearwood is still unnecessarily lost. In Tasmania, stands of old growth ash eucalypts, whose clearwood sheaths are measurable in feet rather than inches, are sawn to bolts — only to be ground into newsprint. While New

Zealand is currently exporting enough untended logs to supply a large newsprint machine, the next such machine being installed in Australasia is in Tasmania, where it will be supplied with logs of a far higher sawtimber quality than those of New Zealand log exports. Simultaneously, an additional 20 million cu. ft of logs annually was successfully tendered for by the New Zealand company, currently making newsprint, for manufacture into kraft paper in eight years time. It could be reasoned that national planning would favour making newsprint now (though world export prices are still falling). The Australian and New Zealand newsprint companies are linked by capital exchanges of 2 million ordinary shares (Tasman Pulp & Paper Co., 1963) and have, no doubt, sensible reasons for their policies; but it is expecting too much of mutual planning to avoid the complex contradictions apparent in the current use of forest resources by private companies and by State Forest departments. How much more difficult would it be to decide forest planning on an international basis, under the joint consultative council, part of whose function is ". . . promoting the most efficient use of the combined resources of both member States"? Private interests will continue, no doubt, to raise problems of the type illustrated. These will be difficult to resolve. In the actual case given it suits Tasmania to utilize its resources in this fashion, while faith in the future of clearwood is demonstrated by intensive pruning; and it suits the newsprint companies who are already financially integrated. It is much more difficult to see how Australasian or even national short- and long-term interests are at all benefited by these paradoxical policies. It will be recalled that the Canberra Pact of 1944 included provision for closer co-operation and ". . . covered nearly everything that the most enthusiastic devotee of greater union could have asked" (Lipski, 1965), including a joint permanent Australia-New Zealand Affairs Secretariat. It was "an abysmal failure" (Lipski, *op. cit.*).

Plans for forestry in each country are for the substitution of indigenous supplies by exotic softwoods and for marked expansion of forest industries — the major reasons for these plans being the high increment rate of such forests and the national policies of autarchy. The plans are far from mutual, and while New Zealand aims at an export surplus — principally to supply Australia — the latter aims at self-sufficiency (Jacobs, 1963). Although ". . . New Zealand's planting programmes aim, as they have always done, not only for self-sufficiency but also for a considerable export surplus" (Thomson and Williams, 1964), the potential supply from New Zealand has been disregarded at times in Australia. The statement: "A New Zealand Forest Service study indicated that the present forest resources of New Zealand are inadequate to meet the likely needs of New Zealand by the turn of the century" (Jacobs, 1963) ignores the planned and publicized intentions of the expanded afforestation programme. A better summary was given by Stevenson (1965) who acknowledged current New Zealand plans for expanded afforestation.

Budgets have not been published on the cost and profit estimates of New Zealand afforestation; these are now available for New South Wales (Lugton, 1968) The benefits, to New Zealand, have usually acknowledged the effects of import substitution and foreign exchange earning, with some mention of rural employment and associated benefits; the implications of full Australian self-sufficiency may cause a re-examination of the place of forestry in the New Zealand economy.

After the first year of operation, the F.T.A. ". . . on balance . . . has brought no marked increase in support for the arrangement, which in New Zealand has never been particularly strong; indeed the disagreement between the Australian Paper Manufacturers Ltd and the Tasman Pulp and Paper Co. about the possibilities of the latter's exporting kraft liner board to Australia is tending, at this stage, to intensify doubts . . . in . . . New Zealand" (Holmes, 1967). "New Zealand criticism of the F.T.A. include the now-vindicated forecast that Australian paper manufacturers would stop, or threaten to stop, buying New Zealand pulp if kraft paper were allowed duty free into Australia (Larsen, 1965). The further objection that the very recent (1964) development of the New Zealand fine paper industry ". . . could be killed in its infancy, but perhaps this is intended" (Larsen, *op. cit.*) remains undecided. Following protests from the N.S.W. Government and other authorities (Anon., 1965b), the F.T.A. excluded the processing of timber where New Zealand has substantial cost advantages (Mason, 1966; Anon., 1965c). One comment on this omission was: ". . . considering that N.Z. has very few chances to make inroads into the Australian market, and that timber and timber products comprise our N.Z. main bargaining-point, it does seem that N.Z. negotiators have very little on which to congratulate themselves" (Anon., 1967). The only sawnwood products which New Zealand has available from the current surplus of first-rotation stands of pines, and as elucidated in extensive grade studies (Fenton, 1967a), are Framing, Factory grade and finger-jointed wood (Mason, 1966; Stevenson, 1965). Douglas fir offers a complementary source of Framing timber (Fenton, 1967b).

The official view "that New Zealand should soon be able to send more sawn exotic timber to the Sydney market" (N.Z. For. Serv., 1966) has no rational basis because (apart from the removal of the recently imposed tariff on Douglas fir) both the market and the timber-quality potential remain unchanged. Similarly, it is difficult to see why "New Zealand now has a wonderful opportunity to increase sales in Australia of the timber products which we [N.S.W.] traditionally import from her duty free or under preferential rates" (Beale, in Anon., 1965b) because — apart from Douglas fir — they were duty free to start with, and further timber *processing* has not been liberalized at all. It is anticipated that the Australian deficit in pulp and paper products, other than newsprint, can be partially supplied by New Zealand; the official viewpoint was: "It is in the field of kraft paper that New Zealand will have a great advantage. The growth in the use of kraft paper . . . . has been phenomenal" (Anon., 1965d). This view, in particular, has been disputed by Larsen (1965) whose argument was that ". . . it seemed completely out of character to expect Australia to change from self sufficiency in kraft and adopting hardwoods for kraft pulps, to accepting New Zealand kraft. The Australian kraft paper company emphasises that its expansion plans alone allow for increase in Australian consumption, and contend that New Zealand kraft can only be sold by dumping" (the F.T.A. includes anti-dumping provisions).

Extension of the F.T.A. to cover the products in which New Zealand has either an apparent comparative advantage or the potential available from its forests should be made if the Agreement is to be anything more than ". . . another chapter in the depressingly familiar story of abortive agreements, editorial hosannas, political platitudes and déja vu enthusiasm" (Lipski, 1965). The timber physically available from the exotic resource has been enumerated earlier (Framing, Factory grade and finger-jointing material), but the historical potential of indigenous softwoods is still available for timber export. Limitations on exports of the latter have been lifted from July, 1967 for twelve months. Currently all grades of all species except kauri can be exported provided that sawmill stocks had been accumulating, and that mill production was not increased above normal for a 40-hour week. The further processing — drying, preservation, finger-jointing and pre-cutting — of both exotic and indigenous wood, including box-shooks, should be included in the F.T.A. if it is to have any important effect on timber exports to Australia.

Further supplies of high grade indigenous timber should be diverted from the prodigal home market, and its role as an export earner could parallel that of, for example, crayfish-tails or carcass-offal as the high-earning export line. The latter products are available in New Zealand, but at a price equivalent to their export, or world, values. The past use of these quality timbers in New Zealand has been wasteful, their export potential being ignored partly because of conservative specifications, their value understated because of price control and the prohibition of exports. One method of ensuring further export availability of indigenous timber would be a re-examination of all building specifications; it is absurd to allow cone-holes, for example, in Australian house floors, but to rigidly exclude them in New Zealand. Further substitution of exotic for indigenous timbers for New Zealand domestic use would increase the latter's export availability. Substitution has been a consistent policy in New Zealand for many years. Forest policies are full of apparent contradictions; but the contrast in equipment in the general run of sawmills cutting high grade indigenous timber, and the far higher standard of mills cutting much lower grade exotic timbers, is nationally a striking anomaly. Improvement of sawmill equipment to produce indigenous timber for export could increase potential earnings, even though the mills' lives are only about 20 years.

New Zealand's rising consumption of newsprint, an item — in contrast to kraft paper — whose cost does not greatly influence the price of other export primary products, could be subdued by imposition of a sales tax on both domestic and imported paper. Admittedly, newsprint is sold on large-scale, long-term contracts, but a slackening of internal growth in demand could stimulate exports. This would be unpalatable to the New Zealand producer; overall reduction in the expansion of the economy itself tends to restrict newsprint sales as advertising decreases. The growth of domestic *per capita* consumption has been from round 33 lb in 1951 to 67 to 69 lb in 1966; present consumption is close to that in Australia.

The failure to extend the F.T.A. to major agricultural produce, and the restrictive application of its apparently favourable clauses on lamb and cheese exports to Australia — now restricted quantitatively to small amounts — indicate, with the converse continued protection of New Zealand manufactured goods, little change in the *status quo*. "The lack of thrust is primarily due to the marked reluctance of both governments to reduce the protection accorded to local producers, in New Zealand's case mainly in the manufacturing sector, in Australia's mainly in foodstuffs. . . . In industries characterized by duopoly or oligopoly [viz. by two or a few producers] . . . the mere reduction of barriers to trade . . . will not be sufficient to permit optimum expansion by the most efficient producers." (Holmes, 1967). There is still no real foundation for a free trade agreement between countries with competitive exports unless far more draconian legislation is passed. There is no counterpart of the E.F.T.A. demolition of tariffs on forest products, for example, which has had a considerable impact on the previously protected United Kingdom paper industry.

In the international trade in forest products, sawn timber and newsprint attract the lowest tariffs and the least discrimination against imports. Concentration on these products could eventually enable New Zealand to diversify markets (if not categories of forest-product exports). Diversification into expanded kraft paper production to gain the benefit of a high joint Australasian tariff is at the risk of eventual loss of such a market through renunciation of the F.T.A. or, more distantly, by the greater development of Australian forestry and its ability to supply the Australian market if and when afforestation targets are achieved.

The F.T.A. is initially for 10 years, after which it can be revoked at six months' notice. The ultimate aim of Australian self-sufficiency in forest products makes future (post A.D. 2000) marketing of New Zealand produce there doubtful.

New Zealand depreciation, and Australian appreciation of currency in late 1967 will have complex effects. The new level of export prices will be determined after the increases of variable and of fixed (capital) costs in New Zealand have been assessed; international freight rates and the price policies and sales contracts of exporting companies will also affect the final prices. An interim assessment of devaluation effects has been made by the Forest Economics Division of the New Zealand Forest Service Head Office, to whom acknowledgement is made for the following data on changes in production costs in New Zealand:

(a) Logging costs increase by 3% net at port.

(b) Sawmilling costs increase by 2% net at port.

(c) Pulp and newsprint costs increase by 5% net at port.

(d) Trans-Tasman shipping freights are at present (December, 1967) unchanged.

Overall, New Zealand exporters have an opportunity for at least an interim increase in profit and/or a decrease in price on the Australian market. It is possible that the values of the Australian and New Zealand currencies will change further, to New Zealand export advantage, over the next two decades. Other changes — particularly the merging of national sovereignty — would be largely to New Zealand's economic advantage, but are less probable. Political union with Australia is the least unlikely of such mergers, but logically union could occur with other nations. Any of these possibilities would greatly change the comparative advantage of New Zealand as a forest products supplier but, as her experience in meat and dairy export products shows, the classical arguments of comparative advantage are of dubious application in world trade for a small country with a limited range of exports.

New Zealand, owing to a restricted range of natural resources, is destined to remain a nation dependent on trade. The rates of return from forestry in New Zealand are not appreciably different from those in agriculture (Ward *et al*., 1966), which is the principal source of export income. Forestry's prospects are as dependent as agriculture's on the vagaries of other countries' import policies, but forestry does provide one of the few export alternatives for New Zealand's limited resources.

The future Australian market is conjectural; if the Australian afforestation programme is fulfilled and consumption projections are correct, it is unlikely that much could be sold there. The major decision — whether Australia should even aim at self-sufficiency or rely partly on New Zealand supplies — has already been taken; it is ironical that this occurred while the F.T.A. itself was being decided. It aptly illustrates the reasons already given for past poor trading relations: ". . . the rather exuberant nature of Australian nationalism has fostered an unwillingness on the part of Australian politicians and officials to make concessions to N.Z. viewpoints, while N.Z. parochialism and insularity have reinforced the complacency of the New Zealanders about the world they live in" (Robinson, 1965).

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